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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN, THE NATIONAL IRONFOUNDING EMPLOYERS' FEDERATION, THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

JANUARY 15.

Institute of Metals (Scottish Local Section):—Meeting in Glasgow at 7.30 p.m. "Factors in the Solidification of Molten Metals," Paper by Sydney W. Smith.

JANUARY 16.

Institute of Metals (Birmingham Local Section):—Meeting at The James Watt Memorial Institute, Birmingham. "Electric Welding," Paper by C. A. Hadley.

Institute of British Foundrymen.

JANUARY 19.

Sheffield and District Branch:—Meeting at Grand Hotel, Sheffield, at 7.45 p.m. "Patternmaking from the Foundry Point of View," Paper by E. Longden.

JANUARY 20.

East Midlands Branch (Lincolnshire Section):—Meeting at Technical College, Lincoln, at 7 p.m. "Modern Cupola Practice," Paper by H. H. Shepherd.

Newcastle-upon-Tyne and District Branch:—Meeting at Neville Hall, Newcastle. Paper on Patternmaking (details to be announced later).

Scottish Branch (Falkirk Section):—Meeting at 6 p.m. "Recent Developments in Foundry Melting Practice," Paper by H. Cowan.

JANUARY 27.

Scottish Branch (Edinburgh Section):—Meeting in the Heriot Watt College, Edinburgh, at 4 p.m. "Problems in Woodworking Machinery Castings," Paper by R. Ballantine.

East Midlands Branch:—Meeting at Loughborough College at 6 p.m. "Some Non-Ferrous Foundry Problems," Paper by F. Dunleavy.

Lancashire Branch (Junior Section):—Meeting at Manchester at 7 p.m. Lecture by H. E. Beardshaw.

The Reorganisation of the Steel Industry.

Rumours are current that the ratification of the proposals for reorganising the iron and steel industry will not be long delayed. A significant factor is that an agreement has been reached between the British and Continental steelmakers, which assures a narrowing of the differential paid by Continental and British ship repairers for the steel plates. As ship repairing often and usually involves castings, this is all to the good of the British foundry industry. The envisaged reorganisation of the steel industry involves price control, manufacturing quotas and elimination of redundant plant, but whether the last factor has been embraced in the scheme is not apparent, nor is that of the quota system. As trade conditions improve, these two factors become less and less important, for under boom conditions plant normally describable as semi-derelict is capable of earning good profits. The proposed scheme, however, looks farther ahead, and is legislating for both altered politico-fiscal conditions and the next trade depression. With expanding markets, employer co-operation is not so essential, superficially at least, as during a period of contracting markets, when price cutting may render the whole efforts of an industry, not merely nationally but internationally, abortive from an economic standpoint. With the institution of the reorganisation scheme, there will be an effort made to impose a series of loyalty and interlocking rebates, which will tend to bind industry in general, from first producer down to the ultimate consumer, in such a way that all will play the game as a team having purely residential qualifications. Modern industrial conditions are so delicate that it seems desirable that no one firm or individual should have such a dangerous weapon as uneconomic price cutting placed in his hands. The incentive of quality and service must be the paramount factor in influencing order. In the old days, when certain markets, as, for instance, the local consumers in a district, were assured, there was no need for such co-operation; but to-day, even inter-departmental work has often to meet competition of a nation-wide, or perhaps even international, character. Thus, a really bad price cutter can leave a train of disaster over a much wider area than he envisaged when he first set out to capture or retain some comparatively insignificant order.

The foundry owners will watch with much interest the endeavours now being made in the reorganisation of the iron and steel trades, as their own business careers follow much the same trend as the heavy industries.

Rubber as a Competitor.

Many of our readers will have seen with interest, and doubtless some amusement, the pictures and story in the daily Press respecting the use of rubber pillars on island refuges in traffic-ridden roads. Apparently the authorities at Leicester, finding it necessary to replace a few cast-iron pillars each week, due to collisions, produced a rubber pillar which bends under impact and then returns to its position afterwards. We do not think we shall be accused of bias against the attempt of a competitive material to erase the one in which we are interested, if we ask in this connection, when is a road island not a road island? The answer certainly would be, when it is made of rubber. To complete the matter we should only require to develop rubber pedestrians who would spring back to the vertical after a car has passed over them. We imagine that the motorists' knowledge that refuges are made of stout stone and cast iron is the best guarantee of safety that the pedestrian making use of them can have, as well as the best guarantee to the motorist that, in the event of an inadvertent collision, the damage would not be so great as if the refuge were made of a material capable of standing up like the Rock of Gibraltar against anything.

C

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Theory and Practice.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The foundry trade has been deeply interested in your recent Editorials and Correspondence relating to Theory and Practice, Education and Technical Control of Foundries. So far as technical control of foundries is concerned, it means finally and in effect the executive control.

Fortunately or unfortunately sand control and metallurgical control does not function from the professional laboratories except in a few cases. Nor can the professional lay exclusive claim to the act of control. Surely the general foundry is a veritable and practical laboratory.

In the first place, so that I may not be misunderstood, let it be stated that it is absolutely necessary and inevitable that the modern foundry should receive specialised and professional help such as for mechanisation, which includes foundry engineering, pattern work for general and quantity production, and metallurgical and general chemical control of foundry materials. The cost of obtaining this help is of profound importance to the foundry trade.

It is truly alarming to note the multiplication of research, professional and technical Institutes, Societies and Guilds.

What an enormous impetus would be given to production and costs if all the dissipated and decentralised efforts we see being made in the foundry trade could be concentrated substantially in the hands of a Parent Technical and Research Association which could function as a directing head and clearance-house for all efforts.

Since cast iron constitutes 90 per cent. of all metals cast the pivot could be The British Cast Iron Research Association. Such a co-ordination of effort would therefore be possible in widening the scope of the B.C.I.R.A. by this main research organisation absorbing the smaller Cast Metals Research Associations. It could very well be named The Cast Metals Technical and Research Association of Great Britain. The excellent manner in which the B.C.I.R.A. has progressed under considerable restrictions and bad trade is proof of the worthiness of its elements—personal and otherwise.

The ideal in Britain would be the organisation of a Parent Technical Research Association consisting of Metallurgical Research and Analytical Laboratories. It would then be possible for the smallest foundry to be supplied with cheap standard reliable analyses and to have special problems looked over through the eyes of the research authorities.

The National Cast Metals Technical Research Association should have Government support, which support and power might be used to compel all foundries through Company Law to belong and contribute to the National Association.

Britain is not a very large nation, and modern means of communication are excellent. It would be possible, therefore, for a producer within 24 hours to receive the analysis of a particular sample at a low cost from the Parent Laboratory.

The principle factors in reducing costs in the the general foundry, which exceeds the repetition foundry as 6 to 1, are: general organisation, good moulder-coremaker craftsmen, generous foundry tackle, foundry equipment which includes modern sand mixing plant, moulding machines, well constructed melting plant, and economical metal mixing. The repetition and semi-repetition foundries can go much further and incorporate continuous casting plants.

Mr. Charles Northey in his letter to your columns of January 4 aptly summarises the inherent attitude of the successful British foundry owner to the practically-trained technical foundryman.

Unfortunately theoretical and technical education as supplied by Universities will not provide what is needed in the foundry trade. It would certainly provide research workers for a National Cast Metals Technical and Research Association, although the same body could institute its own education section, which would prove very complimentary and helpful generally.

In great danger of being misunderstood I venture to state, emphatically, that I would far sooner employ as a general moulder the average man over 40 years of age than under. I make this statement in reply to the gentlemen who state that fortunately the old type of foundryman is fast dying out. It has been the unfortunate experience in the foundry that theoretical and technical training has not produced any better moulder and coremaker craftsmen than hitherto, and they are the pivot of production.

It is an extraordinary psychological fact but true that 95 per cent. of those who receive external foundry theoretical and technical education consider themselves in time to be above doing practical work and very superior to the man who can do practical work only. They in fact too often consider themselves ripe for the chair of managing director. The remaining 5 per cent. make real all-round foundrymen, who should be looked out and given the opportunity to rise to executive positions. This select 5 per cent. is likely to possess that balanced and thoughtful personality which is so necessary to supervise and direct foundry workers, and also organise technical and scientific control of a practicable order.

Whilst not believing in the continued multiplication and extension of technical organisations, and whilst the practical craftsman is likely to be dwarfed in his importance by the more articulate or wordy in the present societies, I would support Mr. Northey in forming a new Institute to be named the Institute of Engineering Craftsmen.—Yours, etc.,

E. LONGDEN

(Foundry Manager, Craven Bros., Limited, Machine Tool Engineers, Manchester).

What is a Metallurgist?

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The Leader which poses the above in your current issue deserves solving, if agreement is feasible. It is, like many queries, more easily answered the less one knows of the subject; it may, therefore, remain an open question.

I would hazard: A metallurgist is one versed in some of or all the science and art of extracting metals from their ores and of preparing them, otherwise than mechanically, for use.

The metallurgist, on this basis, is both a chemist and a physicist. A foundry manager who is qualified to prepare his metal for use, that is to say to produce suitable metal and to cast it to the required shape in a desirable manner, is a metallurgist. Lines 6 to 10 of your Leader are not in accord with this definition. They are more in line with the general idea that a metallurgist is a man who analyses metals and speaks words of wisdom from behind a microscope. One can seriously doubt whether such an adept is, at all, a metallurgist. As analyst, he is finding out the existing composition of a substance, as microscopist, he is observing the existing constituents of a substance. He is not engaged on producing or preparing one state of metal from another state.

The metallurgist must fully understand the purport of analytical and microscopical observations, just as he must those of mechanical tests on his metals; but the routine manipulations necessary to obtain these are not his direct concern.—Yours, etc., VICTOR STOBIE.

South Drive, Harrogate.
January 5, 1934.

Quantity Production and Steel Castings.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—It was with great interest that I read the letter which had been addressed to you by Mr. F. A. Melmoth, of Detroit, U.S.A., and published in the December 21, 1933, issue of the FOUNDRY TRADE JOURNAL.

The point at issue appears to me to be whether I was justified in referring to mass production of steel castings in America, or that the import of my statements had not been grasped by Mr. Melmoth. I think the latter is the case.

I want to be as brief as possible in this reply, as it is not my intention to encroach on your valuable space to a greater extent than is necessary, and I am not too anxious to engage one of our friends in God's Own Country in wordy warfare, because I am aware of their reputation as to being able fluently to state their own case.

Mr. Melmoth has unfortunately taken it for granted that I would encourage British foundrymen to ignore repetition production, and that I would advocate that production throughout the steel-castings trade should be on jobbing-foundry lines. I derived some gratification from the fact that my good friend admits the difference between "repetition produced" and "mass produced." Do we in this country not throw up our hands in glee when we see in our morning mail an order for 50 to a 100 off one particular pattern? Or sometimes (but very rarely) even greater quantities. That job moves quickly. We are all agog to get pattern equipment through. Another job for the moulding machines. My word, we are happy! Yes, repetition production, until these particular items are cast and knocked out. But what then? My statement, to which Mr. Melmoth takes exception, was made particularly with reference to the later stages as to what happens after these operations. Mass-production methods are applied in America until despatch is effected, but with few exceptions it is not so over here. The accepted practice in America, of cleaning steel castings, cannot be compared with ours, as (again with few exceptions), they shake out, roughly grind where heads and runners have been placed on the castings, leave brackets and fins on, and, generally speaking, despatch in a semi-finished condition.

Whilst we are always trying to instal machinery and mechanised equipment in the moulding shops, and gasp for those orders which allow us to go into repetition production, it is not so easy to mechanise our fettling shops, because of the demand for clean and smoothly-finished castings. The majority of inspecting engineers and customers' representatives over here demand the removal of all superfluous material, such as brackets, fins, etc., any small defects made good by welding, and almost invariably insist on a really good clean finish to the castings. This was what I had in mind when referring to the advisability of adopting mass-production methods, and whether we could afford to do so in view of the demand. I am not prepared to say that our engineers should lower their standard of required finish, but as foundrymen we are justified in reminding purchasers that their standard *is* high, and, in consequence, it costs money in our fettling shops to effect that finish, which must necessarily affect our selling prices.

From the foregoing remarks I trust Mr. Melmoth will accept the fact that we in this country, whilst not to the extent that is possible in America, do seriously consider repetition production, and that when sitting in judgment over me on this subject of mass production, he will concede a point or two in that the demand does have a bearing as to what extent mass production may be adopted in our shops.—Yours, etc.

CHAS. D. POLLARD.

"Belmont," Avenue Vivian,
Scunthorpe, Lincs.
January 9, 1934.

The Addition of Non-Ferrous Metals to Cast Iron.*

By J. E. Hurst (Vice-President of the Institute of British Foundrymen).

For many years the addition of various non-ferrous metals to cast iron has aroused the interest of investigators. It is probable that this interest is in the main inspired by the marked changes in properties and outstanding advantages of considerable commercial value which have arisen from the use of similar non-ferrous additions to steels. In spite of persistent efforts, with one or two exceptions, very little headway in the application of alloy additions to cast iron has been made, until recent years. Two notable exceptions are the high silicon acid-resisting cast iron and the nickel

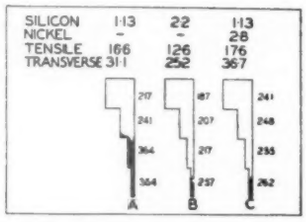

FIG. 1.—INFLUENCE OF NICKEL ON CAST IRON.

manganese austenitic cast iron known as No-mag. The former is a cast iron containing from 12 to 16 per cent. silicon. It appears to have been first introduced in France about the year 1900 by Adolphe Jouve, and has been manufactured continuously over this period. No-mag was introduced by Mr. S. E. Dawson of Messrs. Ferranti, and contains sufficient nickel and manganese to render the material austenitic and consequently non-magnetic. A typical analysis shows 10 per cent. nickel and 5 per cent. manganese, and as such very probably marks the earliest commercial development of the austenitic cast irons.

Apart from these, the only progress made up to a few years ago appears to have consisted of the intentional addition of small quantities of such elements as copper, nickel, aluminium and chromium to cast iron on the part of a few individual foundries, and there is evidence that, from time to time, attempts were made to develop alloy cast irons of notable alloy content having distinctive properties for certain specific purposes. For example, the author has a record of the examination of special hard cast iron limit gauges supplied by a firm (Tylor & Sons, Limited) in January, 1919. The chemical analysis of one of these specimens was as follows:—C.C., 0.48; Gr, 2.22; T.C., 2.70; Si, 1.48; Mn, 0.57; S, 0.08; P, 0.94, and Ni, 8.23 per cent.

Surely this must be regarded as a very early example of the use of nickel additions to cast iron for the production of the now familiar hard martensitic cast irons. Another example which occurred again during the war period was the use of additions of tin to cast iron. The use of tin additions to cast iron for the production of press tools, particularly for shell piercing, was investigated and developed by Guillet in France, and is fully described in a special volume published by "Revue de Metallurgie" in 1917 entitled "Researches on Shell Manufacture." Incidentally, it was shown that additions of this element considerably increased the hardness of cast iron due to the formation of a compound of tin and iron. It was concluded also that in quantities up to 5 per cent., tin was a desirable addition to castings which are required to maintain a considerable degree of hardness at high temperatures.

Apparent Limitations.

The position as regards the addition of non-ferrous alloying elements around the years 1926 to 1928 cannot be illustrated better than by the following quotation from Dr. Hatfield ("Cast Iron in the Light of Recent Research," 3rd ed., 1928), in which he opens the chapter dealing with the influence of special elements in the following words:—"It cannot be said, as in the case of steel, that the special elements are alloyed with cast iron with great advantage." The author himself in his own book published two years earlier ("Metallurgy of Cast Iron," 1st ed., 1926) expressed a similar view in the words: "Generally speaking, the high costs of the special elements, coupled with the difficulty of melting, casting and manipulating the resulting alloys are of sufficient magnitude to outweigh the advantages in mechanical and physical properties obtained." It is only fair to add that in both cases the view was held that future research might modify this position, and Dr. Hatfield stated definitely that "Future research may modify this view, particularly as regards some of the special characteristics and also as regards resistance to temperature effects." These references serve an additional purpose in emphasising the short period of years during which the addition of alloys to cast iron has become the basis of developments in cast iron metallurgy which firmly established themselves as possessing clearly defined economic advantages. To-day alloy cast irons of high strength properties, capable of being heat treated

FIG. 3.—HIGH-CHROMIUM ALLOY CAST-IRON TRUCK TOP GIVING EXCELLENT SERVICE.

by hardening and tempering and nitrogen hardening processes, martensitic cast irons and austenitic cast irons are freely spoken of by almost every ironfounder, and it is almost true to say are familiar to every moulder.

Deoxidisers.

It is necessary at this stage to interject a remark on the addition of non-ferrous elements to cast iron in the rôle of deoxidisers or scavengers. It is probably true to say that there are few exceptions amongst the non-ferrous metals which have not been suggested, at one time or another, as suitable additions from this point of view. The chief of these metals are aluminium, titanium, molybdenum and vanadium, whilst the elements boron, cerium, zerconium have also been given some prominence. The use of such metals in this capacity is generally restricted to their addition in very small quantities, and their value is generally alleged to arise from their scavenging effect on the dissolved gases with the consequent improvement in soundness of the castings. There is no doubt that, as a result of increased knowledge, experience and investigation, it has become more and more apparent that the addition of even small quantities of certain of these elements is accompanied by important effects, although a good deal of further knowledge is required before

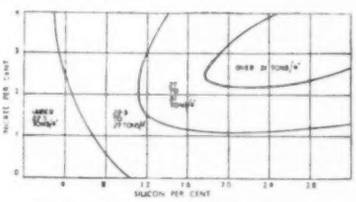

FIG. 2.—SHOWING STRENGTH POTENTIALITIES OF ALLOYED CAST IRON (COYLE).

the mechanism of their action is understood. Whilst the author has not considered this aspect of the subject as included within the scope of this Paper, it is one which should not be lost sight of by all those who are interested in the effect of alloy additions to cast iron. The economic value of any addition to cast iron which will assist in promoting soundness is enormous.

Those non-ferrous elements which are used in the present day production of alloy cast iron are as follow:—(*a*) Nickel; (*b*) chromium; (*c*) copper; (*d*) molybdenum; (*e*) aluminium; (*f*) vanadium, and (*g*) titanium.

In dealing with this subject in accordance with the title of this Paper, it has been considered advisable to confine its scope to this list of non-ferrous alloy additions which are in more or less common use at the present time in the production of commercial grades of alloy cast irons. This list does not purport to exhaust all the non-ferrous alloy additions which have been or are being studied nor to include only those elements which have beneficial effects on the properties of cast iron. It is merely a list of those non-ferrous alloy additions which have become definitely established in present day alloy cast iron production.

Further, it is considered that the purpose of this Paper will be served best by dealing with the various commercial alloy cast irons rather than an abstract consideration of the influence of these elements on the physical and mechanical properties of cast irons. Accordingly the subject has been divided for consideration under the following headings:—(1) High-duty alloy cast irons; (2) alloy cast irons for hardening and tempering; (3) alloy cast irons for nitrogen-hardening; (4) martensitic cast irons, and (5) austenitic cast irons.

HIGH-DUTY ALLOY CAST IRONS.

Nickel and Nickel-Alloy Cast Irons.

It is true undoubtedly that the most important of the high-duty alloy cast irons are those containing nickel, either alone or in conjunction with other elements, particularly chromium. So much has been written and said on the subject of nickel additions to cast iron that it is superfluous to attempt more than briefly to summarise the effect of such. The addition of nickel eliminates chill and hard spots, and as a result ensures improved and

* A Paper read before the Newcastle Branch of the Institute of British Foundrymen, Mr. Carmichael presiding.

more regular machining properties—a matter of great industrial importance in mass production castings. It is also claimed for nickel additions that they equalise the structure in thin and thick sections, thus eliminating the different structures normally developed on account of the different cooling rates of the various parts. The grain of the metal is simultaneously refined, thereby giving higher strength and pressure tightness.

These effects of nickel are summarised in Fig. 1. Diagrams B and C indicate the hardness in varying sections of castings, which have been softened to the same extent by silicon and nickel additions respectively. In general the desired results are obtained in engineering irons by the addition of 1.0 to 1.5 per cent. nickel, accompanied by a reduction in the silicon content of about 0.5 per cent. As an alternative to the reduction in the silicon content, the use of a combined nickel and chromium content is recommended, the chromium serving to harden the iron just as in the case of the silicon reduction. The nickel-chromium additions are generally made in the ratio of three parts of nickel to each part of chromium. A common specification is 1.5 per cent. nickel and 0.5 per cent. chromium. The combined nickel-chromium addition is recommended as being very satisfactory where improved strength, wearing quality or heat resistance is required, but where improved pressure tightness combined with free machining qualities is of importance the combination of nickel with low silicon is to be preferred.

The most recent development in the production of nickel cast irons is of still greater intrinsic importance. This development is covered by the British Patent Nos. 290,267 and 352,510, and relates to the use of nickel for the production of nickel alloy cast irons possessing tensile strengths up to 30 tons per sq. in. A fuller description of the processes of producing these alloys is given in the publication B.15 of the Bureau of Information on Nickel, and consists essentially in the preparation of cast iron alloy of a composition which normally would cast white. When graphitisation of such a cast iron is brought about by the addition of suitable proportions of nickel and silicon a grey alloy cast iron product results which has repeatedly given the remarkably high strength values of 30 tons per sq. in. and uniformity of structure over widely varying sections. It is apparent that for the best results it is of considerable importance to control the total carbon contents, but the diagram (Fig. 2) gives some idea of the strength ranges which can be attained in this type of iron. The facility of production of high strength cast iron of this order is surely an outstanding advantage of the addition of the non-ferrous metal nickel.

Chromium and Chromium-Alloy Cast Irons.

The use of chromium additions in conjunction with nickel in the production of high strength alloy cast iron is becoming more and more appreciated. This element is used alone in quantities of 0.25 to 0.75 per cent. in grey irons, particularly for automobile cylinder castings. Broadly the effect of chromium is to stabilise the combined carbon content, and this addition of chromium to grey cylinder irons is accompanied by the maintenance of a higher hardness level and cylinder blocks, liners and piston rings have been found to have an improved life in service over non-chromium alloy material. A typical series of chemical compositions of chromium alloy cast irons used for cylinder purposes is given in Table I.

Table I.—*Alloyed Cast Iron for the Automobile Industry.*

No.	T. C.	C.C.	Gr.	Si.	Mn.	S.	P.	Cr.	Ni.	Purpose.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
1	3.5	0.5–0.8	2.7–3.0	2.0	0.6–1.20	0.12	0.8	0.2–0.3	Nil	Automobile piston.
2	3.25	0.70	2.55	1.88	0.76	0.082	0.38	0.40	,,	Commercial vehicle cylinder.
3	3.39	0.69	2.70	2.05	0.88	0.091	0.66	0.55	,,	Automobile cylinder.
4	3.62	0.62	3.00	1.54	0.77	0.095	0.40	0.68	,,	Diesel engine cylinder.
5	3.15	0.82	2.33	1.68	0.78	0.11	0.72	0.58	,,	Diesel engine cylinder.
6	3.5	0.8	2.7	1.8–2.0	0.4–1.0	0.12	0.40 max.	0.25–0.5	,,	Special for cylinder block.

Plain chromium irons of this type are extensively used for the purposes indicated, and as these are responsible for a comparatively large tonnage of iron castings produced in this country, the use of chromium additions is common.

Chromium alloy additions are used in the production of castings intended for heat-resistance purposes as, for example, fire-bars and castings for furnace parts. The addition of chromium in quantities of from 0.25 to 1.0 per cent. to a white base iron has found extensive application for those castings required for heat-resisting purposes on which no machining is required. Typical examples of compositions of alloy cast irons of this type which have come to the author's notice are given in detail in Table II.

Table II.—*Chromium Heat-Resisting Irons.*

Spec. No.	T.C.	Gr.	Si.	Mn.	S.	P.	Cr.	Purpose.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
1	3.21	Nil	0.98	0.38	0.11	0.54	0.43	Firebar.
2	3.49	,,	0.75	0.54	0.10	0.11	0.75	Furnace door frame.

The addition of chromium has been resorted to in the production of cast-iron rolls. A typical range of compositions for this purpose is that disclosed in U.S.A. Patent No. 1,702,128 by the Mester Machine Company as follows:—T.C., 2.0 to 4.0; Si, 0.5 to 2.0; Mn, 0.1 to 1.5; S, less than 0.2; P, less than 0.3, and Cr 1.8 to 4.0 per cent.

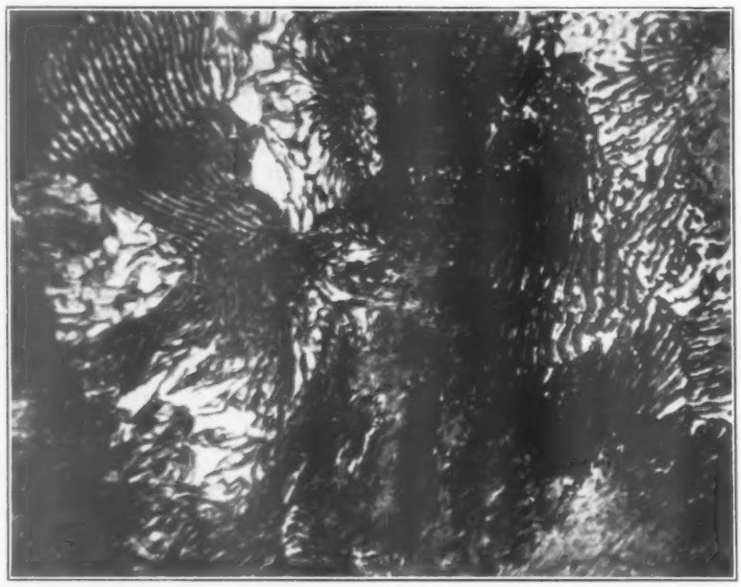

Fig. 4.—Copper Cast Iron, Etched 2 per cent. Mital. × 2,000. (McPherran.)

The use of very high chromium contents for cast iron rolls has been adopted to a limited extent, and is said to have given satisfactory results. The amount of chromium in this case was 15 per cent. and the full composition recorded is given below:—Total carbon, 3.5; silicon, 0.7-1.0; manganese, 0.3; sulphur, 0.04; phosphorus, 0.03; chromium, 15.0; nickel, 0.5 per cent., and cobalt and molybdenum not stated.

Castings in this material are always white throughout, even if cast in sand moulds, and, of course, require to be specially treated for use as rolls. It is of interest to record that castings of this composition have exceptionally good heat-resisting properties and also find a use for this purpose. The illustration (Fig. 3) is a photograph of a truck top in high chromium alloy cast iron of this composition after service in a continuous annealing furnace for several months. The maximum temperature zone of this furnace is 1,000 deg. C. High chromium cast irons of this type are in use also for annealing pots. Still higher chromium contents in conjunction with high total carbon content irons are referred to frequently as chromium alloy cast irons, but, in view of the fact that these are produced generally in the steel foundry, it is not necessary more than to mention them here as additional examples of the addition of the non-ferrous alloy chromium to cast iron.

Chromium additions are made to cast iron conjointly with nickel, as referred to already, and with molybdenum, vanadium and titanium, as will be referred to later under the appropriate heading.

Copper-Alloy Cast Irons.

There are quite a number of interesting features in conjunction with the addition of copper to cast iron. Actually, this element occurs in ordinary cast irons more frequently

(*Continued on page* 28)

The Training of Foundrymen.*

WITH SPECIAL REFERENCE TO THE FUTURE WELFARE OF THE INDUSTRY.

By H. A. MacColl, B.Sc.

Suppose we consider, by the help of an analogy, the whole question of training the foundryman. Let us put ourselves in the position of a manufacturer who is contemplating entering the market with a new article. Quite obviously several factors will have to receive careful consideration, among them the following. First, what is the demand for the article and how is that demand satisfied by existing conditions? Secondly, what competition exists, if any? Thirdly, can the article be sold at a profit? Let us assume that on examination of the three factors enumerated the position is as follows:—(*a*) A demand exists for the article which is not satisfied by any other existing article; (*b*) competition is non-existent; and (*c*) the manufacturer will be his own customer, in other words, the particular article he proposes to manufacture will be of direct service to him and enable him to achieve greater efficiency in other departments. If, therefore, the cost of production appears high, and doubt exists as to whether the venture will prove profitable, the effect of utilising the article in other departments must be taken into consideration.

Details of Production.

In the first place, raw material will be required. It will probably be found that there is more than one grade to choose from. In one case, perhaps, adequate supplies are available, but processing costs will be high. In another case supplies may be difficult to obtain, but the superior quality will lower the price of the finished article, because we shall be able to omit certain of the preparatory processes. Faced with the necessity of commencing production at the earliest opportunity, we should probably draw from both sources, and later examine the possibility of improving supplies of the better-class material.

The planning department will now be called upon to lay-out the shop to the best possible advantage, and distribute the work in the manner best calculated to derive the maximum benefit from that lay-out. In this connection, the first question to be settled will be the intended output, because on this will depend whether existing plant can be modified to meet the necessary requirements.

At this stage, one may assume that this manufacturer is unable to say definitely how many units he will require per week, or per month as the case may be, and additionally, he is also somewhat in the dark regarding the final details of the design. Under such conditions the best solution will, in all probability, be to lay out the shop for quantity production of a basic assembly, and then finish to slightly different specification, as, and when, the necessity arises.

Applying the foregoing procedure to this domestic problem, in the first place, the foundry employers of this country constitute the manufacturer; the problem under consideration is the production of trained foundrymen.

Is there a demand for trained foundrymen, and how is that demand, if it exists, met by the present conditions? Undoubtedly the trained man is in demand at the present time. During the post-war period, enormous progress has been made in the engineering and allied industries. This has resulted in the foundry being called upon to supply castings capable of withstanding service conditions of a much more arduous nature than in the past. These requirements have been met by the increased use of mechanical devices, the development of scientific control of moulding sands, new melting practice, and the extended use of alloy cast irons and steels, and new non-ferrous alloys, particularly light alloys. All these factors call for foundrymen of even greater ability than in the past. Such men are available but not in anything like the desired quantity.

The question of competition does not arise. Abroad, it is well known that foundry training is in a more advanced state of development than in this country, but the product of that training is not found over here.

Thirdly, can competent foundrymen be produced at a profit? This seems to be a point on which considerable divergence of opinion exists. Generally speaking, the larger employers have realised that it pays, and pays handsomely, to train and encourage their employees in every way possible, and thus assure themselves of a regular supply of skilled labour. Moreover, such schemes have no doubt unearthed much latent talent.

The small employer, on the other hand, does not seem to take kindly to the *rôle* of producer. Such men only appear to be impressed by figures, and, as it is unfortunately impossible to draw up a balance-sheet, crediting outlay on apprentice training, and debiting the resulting benefits in terms of pounds, shillings and pence, it is an uphill task to convince such men that it will pay them to cast their bread upon the waters, and give their whole-hearted support to training schemes.

Raw Material.

Having decided that a real need exists for the contemplated product, one must next deal with the details of production. It was assumed that, on investigating this problem, our manufacturer found more than one grade of material available, namely, a low-quality material available in quantity, and a better-class material with an irregular source of supply. What is the position when one applies the analogy to actual practice? Apparently, little difficulty is experienced in obtaining ample supplies of raw material, to wit apprentices, but the quality leaves a great deal to be desired. Now and again manufacturers do manage to obtain small supplies of better quality, but not often. They must therefore make the best of the material at their disposal, and at the same time devote their attention to improving supplies of better-grade material, in practice, the problem of attracting a better class of boy to the foundry industry.

Difficulties of Recruitment.

It is well known, and has been commented upon by many responsible persons, that the foundry apprentice is inferior to his fellows in other branches of the engineering industry. The author can endorse this opinion both from his past experience as a practical foundryman and in his present capacity as a teacher. The position must be remedied, but how? Let us examine the probable reasons underlying the failure to attract the right type of boy.

In the first place, moulding is a dirty job, and always will be, but, as Makemson has pointed out, in one of his excellent Papers on this topic, the dirt will wash off, and in most cases will wash off very much more easily than the oil and grease acquired in the machine shop.

Secondly, the general nature of the work, coupled with the heat, makes greater demands on a boy's physique than is experienced in the machine shop.

Thirdly, an undoubted prejudice exists against the foundry in the eyes of parents. In the past, the working conditions in the majority of shops were bad. The buildings were ill-lighted, ill-ventilated, and generally insanitary; as a result, the whole tone of the industry was lowered.

Fourthly, it must be conceded that the average boy is ignorant of the fact that moulding and core-making are two of the most highly-skilled trades open to him, and offer him just as much chance of advancement as in any other field.

Finally, there was, until recently, no incentive for a boy to improve his status by means of a professional qualification, such as exists in the engineering trades.

Regarding the first two points, little can be done; the question of foundry conditions can be tackled, however. Modern shops are built with the knowledge that good conditions mean increased output, and better all-round efficiency. It is essential to do all possible to improve the older variety of shop where it still exists.

The ignorance of the boys regarding foundry matters can be tackled by propaganda in which the employers should co-operate with the local education authorities. The average boy is attracted to a particular vocation by what he sees of it. Every boy has ample opportunity of "seeing the wheels go round." In everyday life he is constantly brought into contact with mechanical things. How many boys are there who, at some period of their school life, have not expressed their firm intention of being engine drivers? On the other hand, how many boys have ever been inside a foundry by the time they reach the school-leaving age? There is quite as much in the foundry to attract the average boy as in the engineering shop; one can feel just as much enthusiasm in producing a perfect casting as in producing an intricate piece of turning, whilst any boy lucky enough to see a steel converter in action will vote it a decided improvement on anything he ever saw on a Fifth of November.

If employers would seek the co-operation of the local education authorities in their districts and endeavour to arrange works visits for boys in their final year at school, and would further take the trouble to point out the finer points of founding, then definite interest would be aroused and a better class of apprentice attracted.

Training.

The actual manufacturing process must now be considered, namely, how is the foundry industry to treat its apprentices in order to turn them into good foundrymen. In reviewing this question it has been said that our hypothetical manufacturer would consider the plant at his disposal, and see whether it would meet his needs, or whether it would be advisable to install new plant. Now, making the further assumption that on going into details our manufacturer finds himself faced with the following position, namely, that with his existing facilities he can produce a serviceable article, but the application of further treatment will undoubtedly produce a superior article which will, by its adoption, save him money in other directions.

If he decides on this additional treatment he has two alternatives:—(*a*) He can install the additional plant and carry out the additional process himself and (*b*) he can send the work out to another man who possesses the necessary equipment. If he has a large volume of work it will pay him to adopt the first course, if not, then the latter procedure should be taken.

In practice it is realised that by practical training alone it is quite possible to produce a really sound foundryman, but, at the same time, theoretical training is also desirable, the combination when properly applied constituting the ideal. Practical training can be carried out in the shop, but what of the theoretical side? If there is a sufficient number of apprentices the firm can establish a works school, with a competent instructor, or instructors, and there is no doubt that it will pay in the long run. Makemson has fixed the minimum number of apprentices for such a scheme to be successful

* A Paper read before the West Yorkshire Branch of the Institute of British Foundrymen, Mr. R. D. Welford presiding.

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at fifteen. Where the number of apprentices does not justify this procedure, recourse should be made to the local education authority to provide the necessary facilities for training in the theoretical aspects of foundry work.

At this stage the analogy is in distinct danger of failure. Our manufacturer, when he sends out work to another firm, has to pay for it. Here many default. They co-operate with an educational authority to the extent of inducing the authority to provide facilities for foundry work and advising on the nature of the courses. In other words, a group induces an outside firm to install plant specially for its benefit. Industrialists then default by (*a*) not sending the work, *i.e.*, by not seeing that their apprentices attend the classes provided and (*b*) not paying for the work. With regard to the last point, it should be clearly understood that the payment of apprentices' class fees is not meant, the payment should be indirect, by means of allowing apprentices time off to attend classes without loss of wages, or by gifts of apparatus, etc.

Methods of Training.

Many of the large firms adopt the first alternative of the manufacturer. They install plant and complete all operations themselves, that is to say, they undertake the complete practical and theoretical training of their apprentices, the former in the shops, the latter by the establishment of a works school. Many advantages accrue from this system. In the first case, it is possible to achieve perfect co-operation between the theoretical and the practical classes. Secondly, the work is done during the day when the boys are fresh. Thirdly, the time of the classes can be arranged to suit the employers' convenience. Fourthly, the employer is relieved of the responsibility of exercising any form of supervision over the boys outside their normal working hours. Lastly, the more intelligent boys are at once brought to the notice of the employer. This system is in vogue in several large shops in this country, the Continent and the United States of America, and has in general given every satisfaction.

Firms employing only a small number of apprentices, however, constitute the main bulk of British foundries. It is a lamentable fact that in the past many of these small employers have largely neglected the theoretical side of apprentice training. There can be no doubt concerning this fact if the existing facilities for such training are examined.

Three or four years ago Dr. Ingalls, of the Constantine Technical College, Middlesbrough, sent a questionnaire to twenty-seven of the leading technical colleges of the country. Only fourteen of the colleges approached provided courses in foundry subjects. Secondly, all colleges in general complained bitterly of the poor support accorded to the classes. Thirdly, as a result of his inquiries, Dr. Ingalls estimated that the total number of foundry apprentices receiving instruction was in the region of two hundred only. When it is realised that there are more than three thousand foundries in the country, it is obvious that there is something radically wrong when such a deplorable state of affairs can exist. Many people have drawn attention to the apathy of the boys. It is suggested in all seriousness that the employers are just as much to blame.

Some employers will no doubt argue that they cannot be saddled with the responsibility of seeing that their boys attend evening classes. Such difficulties are overrated. If an employer makes it quite clear that preferential treatment will be given to boys attending evening classes, offers some little inducement in the form of a prize, to be awarded on the results of the class examinations, and generally shows the boys that a real interest is being taken in their work, the aforementioned responsibility should cause him little loss of sleep.

One hesitates to recommend that compulsory attendance at classes should be made the rule, but at the same time there is much to commend such a procedure. At fourteen the average boy cannot be expected to recognise all that may be good for him, therefore it is advisable to guide him. If a boy is told in the first week of his apprenticeship that he must attend classes he will in general accept the edict of the employer without question, the school influence not having been lost. On the other hand, if the boy is allowed to reach, say, sixteen before attempting to get him to attend classes, two facts will have to be faced. First, the boy will now have to spend time in revising his elementary-school work, time which might profitably have been spent in other directions; secondly, being now at an age when he has probably developed other activities, there will be a distinct tendency to arouse the latent spirit of opposition which exists in the best of us. The pill can, of course, be sugared by granting the boy time off on the day of the class without loss of wage.

The above difficulties can be overcome by the simple expedient of allowing the boy to attend day apprentice classes. The boy has no grouse on the score of loss of wage, he is fresher and better able to assimilate the matter put before him. Where day apprentice classes are not provided any local education authority will be only too glad to co-operate with a group of employers in establishing such.

Practical Training.

The practical side of foundry work is something which cannot be accomplished in a technical institution except in exceptional circumstances. At Loughborough College, Leicestershire, however, the College foundry is as large and well equipped as very many trade shops. Foundry work forms a part of the engineering courses, which extend over a period of five years. The students spend alternate weeks in the shops, and in studying the theoretical side of the work. In the shops, full factory time is worked, and under such conditions, a full-time foundry course over a period of years should enable the recipient to obtain a full and comprehensive knowledge of moulding. Such cases are, however, quite exceptional.

To be of real value, the practical work of the apprentice should be systematised; yet how often is *real* system found in practice? Generally, the boy commences as an odd-job assistant on the core bench. He gets moved on to the floor when the whim strikes the foreman, or when pressure of work makes it necessary. He is next put to work with a journeyman who is "supposed" to supervise him, graduates to small work performed on his own, then acts as assistant on larger work, and so gradually acquires his experience. In the past, when operations in general were conducted in a more leisurely fashion than at the present day, such methods did turn out skilled craftsmen, primarily, because the foremen and journeymen of a couple of decades ago could afford to devote time to keeping a watchful eye on the apprentice and giving him some real tuition. Nowadays, the old order of things has changed. Industry expects the same, or even greater, output per man, for fewer hours worked, so that working under such conditions the boy does not get a square deal.

There is no doubt that practical training should be definitely linked up with the theoretical side. This can only be accomplished by co-operation between employers and education authorities. Suppose apprentices from a dozen foundries attend the same course at the local evening schools; then, very little imagination is necessary to see the enormous advantage which would be gained if they all took exactly the same practical training. At present a boy comes across a problem in his practical work, and may have to wait months before the same point is dealt with from the theoretical aspect; then, after such a lapse of time he may fail to recognise the application of the theory to his past difficulty. It is felt, therefore, that a real need exists for organised practical classes. These should take the form of organised instruction on, say, half-a-day a week, carried out in, say, the largest foundry in the district, or the one best able to accommodate the class. In such a class the boys should pursue a systematic course in core-making and moulding, quite irrespective of the class of work they are engaged on in their respective shops. In this manner the theoretical instructors could make the theory very much easier to assimilate, by constant reference to the concurrent practical work.

The establishment of such a class would be fraught with many obstacles, but these should not prove insuperable. First, there is the question of cost. This would include the wages of the instructor, any special material required, loss of the boys' time, etc. If spread over several firms, this is not a large item, whilst the systematic training should increase the efficiency of the apprentices and offset some, if not all, of the cost.

Whilst the need for organised practical class work has been stressed, it is also of the utmost importance that the boys are moved about systematically in their shop work in order that they should acquire as wide an experience as possible. A definite scheme should be mapped out, the boys spending so many months in each of the following departments, core bench, light bench moulding, advanced core work, floor work in green and dry sand, and loam moulding.

Perhaps the lack of such organisation is yet another contributory cause to the failure of the foundry industry to attract the best type of boy.

Theoretical Training.

Theoretical work should be dealt with in a works school, evening technical school or by means of day apprentice classes at a technical school or college. The amount of time to be devoted to such training should be considered carefully. Two evenings or one half-day a week should be devoted to this purpose if maximum benefit is to be derived. In teaching foundry subjects, one is immediately placed at a disadvantage, owing to the fact that a knowledge of certain subsidiary subjects is necessary in order to understand the foundry work. It is essential that the boy possesses a knowledge of elementary chemistry, physics, mathematics and engineering drawing. No doubt, it would be a great advantage to the teacher if these subjects were acquired before commencing a study of foundry subjects proper, and in the past the author pleads guilty to stressing this point in connection with foundry and metallurgical courses.

In the light of greater experience he has had ample opportunity of realising the error of his ways and the wisdom of running the subsidiary subjects concurrently with the foundry lectures. There is no need to look far for the reason. In the absence of compulsory attendance, a boy may come voluntarily and enrol for a foundry course, then, if one is going to retain his interest, he must be given foundry work straight away. This statement is made because many a boy has started a course of foundry work and spent the whole of his first year studying subsidiary subjects. At the end of the year many boys have had enough; perhaps the foundry has never even been mentioned the whole of the year; result, when the next session comes along the boy is missing. It will, of course, be realised that these difficulties will largely disappear if the problem mentioned earlier is overcome, namely, attracting a better class of apprentice to foundry work.

Regarding the actual course, let us return to the analogy portrayed earlier in the Paper. In planning production, we decided on a basic assembly which could be modified from time to time to suit requirements. The analogy is applied in this particular instance in the following manner. All apprentices should be trained to a certain examination standard. This constitutes the basic assembly, namely, the skilled workman. Modifications are then undertaken in the form of further training, in order to produce foremen, charge hands and managers.

Until comparatively recently, those in the foundry industry were without any examination suitable for their particular requirements whereby they were able to assess the value of their apprentices, bearing in mind the fact that the examination system is itself open to criticism. In 1929, however, there was inaugurated a National Certificate scheme sponsored by the Institute of Mechanical Engineers, after consultation with the British Cast Iron Research Association and the Institute of British Foundrymen, whereby the first-named body agreed to initiate a modification of its own National Certificate in Mechanical Engineering, which would be suitable for foundry students.

Briefly, National Certificate courses are organised along the following lines. A candidate for a certificate, having completed two preliminary years in a branch evening school, embarks on a four-year course at a technical school or college. The college may under certain conditions admit candidates to the course without the preparatory years, but one extra year must then be spent at the college itself.

The candidate then pursues a four-year course for which no set syllabus is laid down, but each college submits courses to the Institute of Mechanical Engineers and the Board of Education for approval. These courses will, however, be based on recommendations from the bodies mentioned, modified to meet local requirements. At the end of each year, examinations are held which the student must pass before proceeding with the following year's work, his attendance must also be satisfactory.

At the end of the second year (for candidates who have done two years in the branch schools) or third year (for candidates excused branch-school work) the examination is conducted on slightly different lines. The examination papers have to be submitted to an independent assessor, who has the power to make such alterations in the questions as he may deem necessary. He also scrutinises the candidates' scripts and may modify the marking. Success in this examination leads to the award of an Ordinary National Certificate. The student may then study for a further two years, which, when successfully completed, and the final examination passed, leads to the award of a Higher National Certificate. The standard of this examination approaches University degree standard, and the Institute of Mechanical Engineers recognise it, as exempting from certain portions of their Associate membership examination.

In 1930 the City and Guilds Institute of London, after negotiations with the Institute of British Foundrymen and the British Cast Iron Research Association, inaugurated a Craft Certificate in Foundry Practice and Science, and also in Patternmaking. This certificate is obtained by completing a three-year course arranged by a technical school or college to cover a syllabus specified by the City and Guilds Institute, and passing an examination set by the Institute. Before embarking on the course, it is desirable that preliminary work in mathematics, physics and chemistry should have been done in branch schools. A college will, however, exercise its discretion in admitting students to the course.

The question which now arises is, which of these examinations should one advocate as constituting the standard of theoretical knowledge desirable for the skilled workman? In terms of our analogy, which examination should constitute our basic assembly?

Comparing the details of the two courses, the National Certificate recommendations show a very decided engineering bias, not unnatural, perhaps, bearing in mind the fact that the course is largely sponsored by an engineering body. The author has had the privilege of reading certain minutes of one of the committees set up to examine this question, and he was very forcibly struck with the recommendations for the Ordinary National Certificate. Without going into details the position is this, that such recommendations, where they have been adopted, make it possible for a student to obtain his Ordinary National Certificate without having received any instruction whatever in foundry practice and only two hours per week (in the year immediately preceding the examination) in chemistry and elementary metallurgy combined.

The Higher National Certificate is very definitely above the standard required by a skilled workman, so that one must assume that the Ordinary Certificate *was* considered suitable to meet his requirements. With this assumption, if correct, the author is in flat disagreement. The City and Guilds Certificate, in contradistinction to the above, specifies a syllabus wholly concerned with foundry work with the exception of calculations and drawing, which are very necessary adjuncts. In the light of the above considerations, therefore, it would seem advisable to recommend the adoption of the City and Guilds Certificate as the recognised standard of theoretical proficiency to be acquired by the skilled workman.

No reference has been made to division of the theoretical work, and the number of hours to be allocated to any particular branch, because this is a matter of internal organisation in the school or college. Given a set syllabus, educational authorities will arrange such matters in the light of their experience.

Training of Foremen and Managers.

It appears to be the general consensus of opinion that foundry executives should graduate from the foundry floor, and the needs of the industry be supplied by special training of outstanding apprentices. That being the position, our potential executives would first take the City and Guilds Certificate. What are such boys to do when this has been accomplished? If an embryo executive is precluded from this procedure, he is faced with the unpleasant fact that it will be necessary for him to start again at the beginning of the ordinary course. Had it been foreseen that the boy would prove suitable material for higher training, he could have been started off straight away on the National course. Unfortunately, one cannot take a group of apprentices straight from school, or even after branch school work, and say, "We will train so-and-so, and so-and-so, for managerial positions in the future." The boys must be given an opportunity to display their aptitude for the work, before we can plan a future for them.

If the Institute of Mechanical Engineers *will* accept such students, well and good; at the same time, it then becomes difficult to see what useful purpose the Ordinary Certificate examination serves, except as a medium for a certain number of individuals who will be predestined for managerial posts by virtue of special conditions.

If the Institute of Mechanical Engineers will not accept such cases, the remedy would seem to lie in the establishment of a higher-grade City and Guilds Certificate, or, alternatively, the establishment of a suitable examination by the Institute of British Foundrymen, such examination to constitute a qualification for full membership. Such an idea as the latter is not new. It has been mooted many times in the past, and sooner or later will have to be adopted in order to put our Institute on a level with similar bodies.

To sum up, then, facilities for training foundry executives are only available at present in the shape of the Higher National Certificate courses (University courses in metallurgy do not in general cater for the special needs of the foundry man). On considering the recommendations for the Higher National course, the author feels that, if the student is going to study all the details enumerated, the various branches must only be treated in a very superficial manner, and the student will not gain the deep insight into fundamentals which is desirable for the present-day manager; he will acquire a smattering of a large number of metallurgical facts, without any great knowledge of any of them.

To produce the best type of manager, full-time instruction is desirable, this extending over a period of two or even three years. This full-time course should confer a good general metallurgical training in the properties and uses of iron and steel and the chief non-ferrous metals and alloys. Courses in metallography, refractory materials, analytical chemistry, etc., together with a study of economics, business methods, office routine organisation of labour, etc. Finally, lectures on foundry practice, including moulding, melting practice, casting, pyrometry, etc.

The Main Difficulty.

Such courses are unobtainable in this country, and in this respect we are very definitely behind our Continental neighbours. Germany, France and Belgium all have well-established Institutions where such facilities are available. The need for such courses has lately been realised in this country. Dr. Ingalls, at Middlesbrough, has inaugurated a full-time course for foundrymen. The author has, however, no information regarding the success or otherwise of his venture.

This year Prof. Andrew, of Sheffield University, has made proposals for the establishment at Sheffield of facilities for carrying foundry training to a really high standard. Such ventures need the support of the entire industry, and those members of this Institute, who are not themselves employers, have a mission to perform in convincing the industry that this support is vitally necessary, if we are to retain our prestige in the world market. There is room for a highly-trained man in every large foundry for research purposes alone. By this statement the author does not mean the employment of the man on research work, but he insists that every day in every foundry it is probable that some little episode occurs which might lead to sensational developments, if observed in the first instance by a man sufficiently trained to recognise the significance of such an occurrence.

In conclusion, the author suggests that the future welfare of the industry depends upon recognition of the following points:—

(1) The recruiting of a better-class apprentice.

(2) Recognition by employers of their moral obligation *really* to train their apprentices.

(3) Adoption of one definite examination as the standard of theoretical proficiency desirable in the skilled workman.

(4) Support for any scheme which will increase the facilities for high-grade training suitable for the future foundry executive.

Finally, the author would like to take this opportunity to express his thanks to Mr. Forrest and Mr. Neath for providing him with facilities for reading various expressions of opinion on this topic which would otherwise not have been available.

THE CERTIFICATE issued by the Cleveland Ironmasters' Association shows that the net average realised selling price of No. 3 Cleveland G.M.B. pig-iron for the last three months of 1933 was 52s. 4.64d. per ton, which compares with 51s. 7.27d. per ton in the third quarter. Under the sliding-scale formula, Cleveland blastfurnacemen will receive from June 7 an advance of 0.375 per cent.

BIRMINGHAM ANNUAL DINNER.—The date of the annual dinner of the Birmingham Branch has been altered to coincide with the meeting of the General Council, and will be held on January 20 at the Imperial Hotel, Birmingham, at 6.45 p.m. for 7 p.m. Ladies are especially invited, and a dance is being held immediately after the dinner. The Council would be pleased for members of other Branches of the Institute to participate. The cost of the tickets is 6s. 6d. each (excluding wines), and these are obtainable from the hon. secretary, Mr. L. W. Bolton, 21-23, St. Paul's Square, Birmingham, 3.

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Heat and Acid Resisting Alloys.

At the October meeting of the Sheffield Section of the Institute of British Foundrymen, MR. J. FERDINAND KAYSER lectured on "Stainless and Heat- and Acid-Resisting Castings."

The development of stainless steels and heat- and acid-resisting alloys, said Mr. Kayser, had been closely bound up with the metallurgy of chromium and nickel and later to some extent with the metallurgy of aluminium and silicon. Consequently, one had to go right back to the end of the eighteenth century to trace the beginnings of this important series of alloys.

Early Discoveries.

Chromium was described by Vauquelin about 1797, and from then until 1815 he experimented with it to a considerable extent and came to the conclusion that, along with phosphorus and manganese, chromium was the cause of hot and cold shortness in wrought iron. In 1857, Fremy referred to the acid-resisting nature of chromium in no uncertain terms and said that, although resembling manganese and iron in many respects, in the presence of concentrated acids chromium behaved more like rhodium and iridium and that alloys of chromium with other metals often had the same hardness and resistance to the action of concentrated acids as chromium itself. In 1872, the first provisional patent application was made for a corrosion-resisting steel containing chromium, but no final patent was applied for. If one followed the instructions given in that provisional patent specification, one obtained a steel of practically the same composition as the most recently developed stainless steel, *i.e.*, 30 per cent. chromium.

The use of nickel was first suggested at the end of the eighteenth century by Sandy Samuel Hickling, of Birmingham, who obtained patent protection for "combining of iron with other metals to prevent oxidation." Alloys made according to that patent consisted of cast iron or steel, together with from 2 to 10 per cent. of tin or copper or nickel or antimony. In 1838, Mallet stated that it had been long observed how little liable to tarnish or rust native and meteoric irons were those which contained 9.5 per cent. nickel and variable proportions of chromium and cobalt. In 1888, John H. Hall, of Sheffield, was granted patent protection for a steel containing from 2½ to 50 per cent. of nickel, together with chromium, silicon, manganese and tungsten. In the patent specification no direct mention was made of stainless or corrosion-resisting properties, but it was stated that the purpose of the invention was to produce a steel with great strength and capable of receiving a brilliant polish.

An Important Disclosure.

There were numerous other references to chromium and nickel steels throughout the nineteenth century, but the first really significant reference to corrosion resistance did not appear until 1903, when in a British patent granted to a French firm the following significant paragraph appears:—

"The most important modification to which these elements, nickel and chromium, give rise, consists in the important property (which forms the subject of researches of metallurgists at the present time) which they communicate to the said products steels and irons of presenting great resistance to corrosion."

Recent Discoveries.

Dealing with the more immediate origin of heat- and acid-resisting alloys, Mr. Kayser said that their development was due to the work of Mr. Harry Brearley, of Sheffield, Mr. Elwood Haynes and Mr. Marsh, of U.S.A., and Dr. Strauss, of Essen, Germany. These gentlemen conducted their researches independently, although as learned metallurgists they were doubtless influenced to some extent by the results of previous workers.

Mr. Brearley was responsible for the advent, as a stainless and corrosion-resisting steel, of a material containing approximately 12 per cent. of chromium. Mr. Brearley's history of his own early work was published in the "Sheffield Daily Independent," February 2, 1924. Elwood Haynes worked on rather more expensive alloys and he was responsible for the Stellite variety of metals. Marsh sought a wire for electrical-resistance purposes and originated the nickel-chromium and nickel-chromium-iron alloys, and practically all modern heat-resisting alloys have as their base some such composition as was originally used by Marsh for the production of resistance wire. Dr. Strauss has stated that he started his work on the supposition that it ought to be possible to make use of the valuable properties of chromium, *i.e.*, its resistance to the action of oxygen, for the purpose of increasing the resistance of iron against the attack of hot gases. In 1910, he prepared alloys containing from 0.1 to 5 per cent. nickel and from 10 to 29 per cent. of chromium, which were found to exhibit remarkable corrosion-resisting properties. That work led to patents being applied for and granted for nickel-chromium corrosion-resisting alloys in all parts of the world.

The Patent Situation.

More recently, said Mr. Kayser, it had been discovered that the resisting properties of iron could be very much increased by suitable additions of aluminium and silicon. Most of the information concerning those alloys was to be found in patent specifications. British patent No. 322,446 disclosed a metal containing less than 0.15 per cent. carbon and from 11 to 16 per cent. aluminium. French patent 668,009 disclosed an alloy containing carbon 0.8 to 2 per cent. and up to 25 per cent. aluminium, whilst British patent No. 345,693 disclosed a later carbon alloy containing from 17 to 30 per cent. aluminium. American patent No. 1,380,804 of 1920 disclosed a heat-resisting alloy containing carbon up to 0.5 per cent. and silicon 1 to 6 per cent. for the manufacture of case-hardening boxes and the like. A somewhat similar composition was disclosed in a patent issued to the British Cast Iron Research Association in 1929 (French patent 682,435), which disclosed a cast iron containing from 4 to 10 per cent. silicon. The addition of silicon to produce an acid-resisting alloy had, of course, been known for some years, and as early as 1917 German patent 306,001 disclosed a cast iron containing from 12 to 18 per cent. silicon. Another interesting disclosure was to be found in French patent No. 668,009, which described a heat- and acid-resisting alloy containing carbon 0.8 to 2 per cent. and up to 25 per cent. aluminium, together with up to 6 per cent. silicon.

Commencing with a wrought-iron base, Mr. Kayser said that by the addition of suitable quantities of chromium it was possible to obtain a whole range of heat- and acid-resisting alloys. Alloys containing less than 18 per cent. of chromium and not more than approximately 1 per cent. of carbon had outstanding acid-resisting properties. It was, however, necessary to heat-treat such metals in order to develop the corrosion resistance when the carbon exceeded approximately 0.15 per cent. Iron alloys containing from 22 to 35 per cent. carbon had outstanding heat-resisting properties. Unfortunately, with increase in chromium content, the crystal size became so great that the alloys were very liable to fracture under shock, but it was a remarkable fact that if the chromium exceeded approximately 25 per cent. it was possible to hot-work the alloys when the carbon even exceeded 1.5 per cent., whilst alloys containing 30 per cent. of chromium and up to 0.5 per cent. of carbon could be cold-rolled more readily than many stainless alloys containing less than 0.1 per cent. carbon. By adding nickel and chromium to iron the properties were still further improved, and appeared to reach a maximum when the whole of the iron had been replaced by nickel, and one arrived at a composition approximating to 80 per cent. nickel, 20 per cent. chromium.

Compositional Position of Heat-Resisting Alloys.

Useful heat- and acid-resisting alloys, said Mr. Kayser, were found throughout the area indicated in Fig. 1 (see page 28), but only certain compositions were suitable for producing castings; even then the production of sound castings depended upon a correct adjustment of the carbon, silicon and manganese contents. Small percentages of tungsten, molybdenum were also desirable.

The best all-round heat-resisting alloy was one containing approximately 60 per cent. nickel, 20 per cent. chromium, 1 per cent. silicon, 1 per cent. manganese and 0.6 to 0.8 per cent. carbon. Amongst the lower-grade alloys Mr. Kayser mentioned those containing approximately 20 per cent. chromium, 10 per cent. nickel, 0.5 per cent. carbon, together with small quantities of silicon, manganese and tungsten. The action of carbon, said Mr. Kayser, was twofold. It greatly assisted the production of sound castings and materially increased the strength of the material at high temperatures. It was not, however, advisable to increase the carbon beyond 1 per cent., as the alloys then became so brittle as to be unreliable in service unless used at a very low temperature and under conditions where the material might be made very thick.

What Constitutes an Improvement.

Before discussing the properties of heat-resisting cast irons, Mr. Kayser dealt at some length with the question of what constituted an improvement. Suppose, said Mr. Kayser, one produced a steel with great tensile strength and that the price was 2s. per lb. and the elastic limit 100 tons per sq. in. If one then produced a steel with an elastic limit of 150 tons per sq. in. costing, say, 2s. 6d. per lb., it could be definitely claimed that an improvement had been made. If, however, one took the original steel with an elastic limit of 100 tons and by lessening its alloy content one reduced its elastic limit to 50 tons per sq. in. and reduced its price to 1s. per lb., he would say very definitely that that did not constitute an improvement.

Pioneers started to exploit, and did very successfully exploit, the higher grade heat-resisting alloys containing up to 60 per cent. nickel. Ultimately, they found it desirable to replace part of the nickel by iron, and found that for some purposes the metal was improved and that, under certain circumstances, one could indeed leave out the whole of the nickel and produce an alloy containing 30 per cent. of chromium and the balance iron. Those pioneers fully appreciated that by still further lowering the nickel and/or chromium contents, and if instead of using a base which would give a final carbon content of not more than 0.8 per cent., they used cast iron as a base, they would obtain a very cheap metal with very low heat-resisting properties. Such a metal has, however, been recently sold as a new and important discovery, and cast irons containing, say, 16 per cent. nickel, 7 per cent. copper and 20 per cent. chromium have been boosted to a considerable extent. In so far as heat-resisting properties are concerned, such a metal is, however, far inferior to a heat-resisting alloy containing 20 per cent. chromium, 8 per cent. nickel and 0.8 per cent. carbon. Indeed, its properties were much inferior to those of a 28 per cent. chromium alloy which, said Mr. Kayser, was much cheaper.

Development Work Necessary.

Dealing with the use of heat-resisting alloys, Mr. Kayser said that in the early days they

were only used as heat-treatment boxes, but to-day found a much more extended application. There was an enormous field for furnace parts made from heat-resisting castings, and, strange to say, the largest castings and the most heavily-armoured furnaces were being installed in Russia. In this country there was a tendency for furnace armouring to be too thin, with the result that the parts failed and the metals were blamed, whereas the designer was at fault. Great use was being made of heat-resisting alloys on all sorts of steam-producing plant. When used for that purpose, it was usually desirable to treat the castings with aluminium in order to render them immune from sulphur attack. In conclusion, Mr. Kayser said that whilst there were many engineering requirements that could not yet be met by the metallurgists, engineers had not yet fully availed themselves of the metals which were available, and he thought that one of the best uses to which a research department could be put was the investigation of probable outlets for the wonderful alloys already developed and the education of the engineer in their use.

DISCUSSION.

MR. C. D. POLLARD (who presided) expressed warm appreciation of Mr. Kayser's address, but said he regretted that he had not given the typical foundryman the opportunity of knowing something or gaining some guidance in regard to the actual production of stainless and heat-resisting castings. Those who had been engaged in the production of this type of casting knew that there were difficulties that caused them a great deal of worry, and Mr. Kayser and other metallurgists were the people they were looking to for help in overcoming some of those troubles. He (the chairman) invited the foundryman to open up the subject a little by asking questions regarding troubles experienced daily on the floor.

Skin on Heat-Resisting Castings.

MR. J. R. HYDE said he quite expected Mr. Kayser to say something controversial and interesting, and he had done so. At present the type of casting Mr. Kayser had described was of interest to them all, but they did not "get down to it" in the commercial way that Mr. Kayser touched upon. He did not quite know how Mr. Kayser got on when he met buyers and discussed prices, but he admired his courage in preaching that the best was going to be the cheapest in the long run.

There was one point on the foundry side. He wondered whether Mr. Kayser would give them any indication as to the kind of skin they got on the various types of castings he had mentioned.

Adjusting Composition to Foundry Requirements.

MR. KAYSER, replying, said he did not think it was any more difficult to make a casting from a stainless alloy or a heat-resisting alloy than it was to make a casting from mild steel. He could make castings from a 60-20 heat-resisting alloy, but he most definitely could not make a mild-steel casting, for the reason that he had no experience of the technique of melting mild steel. The most difficult metal to deal with was one containing 25 per cent. of nickel and 20 per cent. chromium. They had difficulties which he thought it was up to the metallurgists to solve.

They must search the alloys very carefully and alter compositions until they got something that definitely would balance. At the moment there was a very great tendency to say "We will have a first-grade alloy, 60 per cent. nickel and 20 per cent. chromium; or a second-grade alloy, 45 per cent. nickel and 20 per cent. chromium; a third-grade alloy, and so forth." That was the wrong method of going right into attack. There were present that night representatives of, say, six firms all producing good heat-resisting alloys to a specific analysis, and the reason they were doing so was that it suited the foundry and must suit the foundry. It was easy to meet heat-resisting requirements, resistance to oxidation, scaling, etc., but they must get something which gave a sound casting.

Influence of Elements on Skin.

Though carbon was a most important constituent, and whilst from a casting point of view alone they could make the carbon as high as they like, they must remember that the metal would be more brittle. Another very useful metal was manganese, which gave a nice skin, and silicon helped in the same way. A most dangerous metal from a foundryman's point of view was aluminium. When they added aluminium to a metal it did not merely go into solution in the ordinary way and lower the melting point, particularly if they added it to a nickel alloy. What he thought happened when aluminium was added to a nickel alloy was that the aluminium combined with part of the nickel to form NiAl, which seemed to be insoluble at ordinary casting temperatures. Consequently that metal poured like porridge, and there was endless trouble. They would sometimes find a large amount of aluminium being oxidised in the metal and a quantity of alumina. Consequently, from the foundryman's point of view, aluminium should be omitted. There was one apparently very cheap heat-resisting alloy which contained essentially 10 per cent. of aluminium as the alloy to iron. It had very desirable heat-resisting properties, but was "a brute" in the foundry. There had been claims, made about three years ago, that all foundry difficulties had been overcome, but he did not think that was quite right.

Commercial Methods.

Mr. Hyde had mentioned the buyer, but as most of them knew, he (Mr. Kayser) was not attached, at the moment, to any steelworks, and was not trying to sell anything. Consequently, he could say that the majority of buyers were a curse to the industry. Definitely, they did not help in the slightest. Merely to send out an inquiry and place an order with the cheapest was asking for disaster. Fortunately, the large engineering firms were realising this fact.

He thought the foundrymen must attack the position in the way the Brown-Firth research laboratory was doing. They should tackle the chief engineers and take the matter out of the buyers' hands. He ventured to suggest that the British Cast Iron Research Association ought to do something of the kind. Such work was not debasing science in any way but simply being a help to industry by bringing to the notice of those who did not know the products of those who had the necessary knowledge.

Alloying Elements not Additions.

MR. J. H. KING asked for enlightenment with regard to the addition of chromium and nickel. How was it to be done, from the foundryman's point of view?

MR. KAYSER said he did not think it was possible to do any serious additions of metals in the ladle and for these heat-resisting alloys they needed a real melting unit. Personally he thought there was nothing to equal an induction furnace, but perfectly good results could be made from any type of electrical furnace, and he did not see why they should not be made from open-hearths up to about 15 tons capacity. They must not regard nickel and chromium as additions. They were constituents in the base of the metal itself, but there were general principles of melting which they could not apply. It was highly improbable that the nickel would oxidise. The iron would oxidise first. Similarly, the chromium would go before the iron and the nickel.

They should not consider the nickel and chromium additions in the sense of additions as made to cast iron. They could not be added in the same way, and as a moulder he thought at the very least they must have an arc furnace, preferably high-frequence induction furnace. These were being used in Sheffield, and in Sweden they were using very small open-hearth and arc furnaces, whilst on the Continent they used almost exclusively very high-frequency induction furnaces. One interesting development was that the Germans melted their heat-resisting alloys in vacuum, about one ton at a time. This sounded simple, but the Germans would not allow visitors to have a close view of their methods. They would take anyone through the works, but they said that having found out the methods themselves they were going to keep them to themselves.

Methods of Casting.

MR. J. E. HURST said they had heard a provocative address. A few of them interested in cast iron had heard and taken good note of Mr. Kayser's remarks in regard to heat-resisting cast irons. He was surprised there had not been more questions about the method of handling the heat-resisting and stainless alloys in the foundry. He felt certain that members were interested in methods of casting stainless castings, and if Mr. Kayser could give them information on the methods of moulding, type of sand, etc., for the manufacture of stainless castings, particularly those required to be subsequently polished, it would be very interesting. Did he use oil sand or dry sand, coarse grain or fine grain, etc.? He was sure a lot of difficulty must be experienced from time to time.

Sand Position Unimportant.

MR. KAYSER said that about 12 years ago he had the job of going to Switzerland to start a foundry making heat-resisting alloys, and when he went he was provided with full particulars of the sand to use. He had been in the particular foundry in Sheffield which was making such castings for several years, and he thought he knew exactly the sort of sand to use. But when he went along to the foundry in Switzerland he found there was no sand at all like the sand he had been accustomed to using. He described the sort of sand required, roughly, and they did not take much notice of it. They used their ordinary sand on the job and got perfectly good castings from it. He then came to the conclusion that two methods of moulding and two sorts of sand gave equally good results. More recently he examined sand used in a German foundry where conditions were totally different, and he would hesitate to name any sand. In any one foundry they would find that they came to the conclusion that there was nothing like sand A, and that was true for perhaps three months or six months, and then troubles came again and they found another sand was their salvation. He had never been able to make up his mind as to the best sand to use, and had never come across anyone else able to do so. It had to be admitted that they changed their minds at least every six months. But there was one point on which they never changed their minds, and that was that the moulds must be well made. When they were dealing with cast iron and cheap metals or metals which, if not cheap, could be repaired easily on the surface, they "let it go." They knew there was a slight crush to meet, but they did not bother. But if they dealt with expensive metals their moulds must be absolutely speckless, and there must be no trace of dust or dirt. There was the horrible practice of throwing sand on the surface when casting cast iron, but they must not do anything of the kind with the expensive metals. A large number of defects in stainless steel were due to carelessness. They must also remember that in a stainless-steel casting they were being asked to produce something much more perfect than they were asked to produce previously. Take ordinary machinery castings. They were given a most marvellous polish, and what they saw on the surface was not metal at all. The metal was a long way under there. In other castings they could afford to fill in any defects on the surface, but when they came to the stainless steels one expected that they would

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look like silver, and they were asked to produce something much finer than they had ever produced before. Consequently they must be very much more careful. Then there was the trouble that the metals were all expensive. If they removed metal by grinding and shaping, etc., that meant so much metal lost, but they could not fill these castings with the same ease that they could fill an ordinary casting. Take repairs to a big casting. There was no hope of "burning it on"; it could not be done. They had got to turn to really good welding—perfect welding—and remember that their welding was going to be absolutely exposed. The casting must be definitely clean, and consequently some foundrymen got in a very despondent sort of way and were blamed for things for which they should not be blamed. It must be realised that if a polished surface was required they had to keep the casting skin off. There were always imperfections in the metal, and what was going to happen when it was heated up to 1,600 deg. C.?

Tests at Elevated Temperature.

Mr. R. Lamb said he did not think anyone would disagree with Mr. Kayser when he said that most tests at elevated temperatures were not worth very much. But strength was important and they had to have some sort of value on which to base their design. How did one ascertain creep stresses and could Mr. Kayser give any indication as to the method to apply those figures? So far as he knew, there was only the empirical method of obtaining any useful information. They knew what a casting would stand before it started to sag. In regard to the critical scaling temperatures, he would like to know how these figures could be applied to commercial practice. With an 18 per cent. chromium, 8 per cent. nickel alloy, 900 to 950 deg. C. was given as the critical scaling temperature, but he would hesitate very much before he put in that alloy for that temperature. He did not think it would have an economically long life and he thought the limiting temperature would be about 850 deg. C.

Mr. Kayser said there was not the slightest difficulty in applying the creep stress. He suggested two years ago that at elevated temperatures all metals, below their melting point, had a definite elastic limit and that the true creep stress, once determined, was to all intents and purposes the elastic limit. That view was held by the largest users of heat-resisting alloys in Europe, and parts to work at elevated temperatures were designed in exactly the same way that a bridge was designed. If they had a structure with which they were going to work at 600 deg. C. the creep stress would be 4 tons per sq. in. and they could use that figure exactly as they would use the elastic limit in the case of nickel-chrome structural steel. First of all they would decide on the factor of safety, and if it was a casting they must have a higher factor of safety than with wrought material. With a casting they would work with a safety factor of five. It was not always done, because of £ s. d., but usually structures lasted reasonably well with a factor of safety of 2 to 3. Furnaces were carefully designed in every detail exactly as if they were cold structures and the physical properties followed strain-stress temperature curves. It was impossible to turn to one publication and get all the various stress-temperature curves of metals, but they could find all they wanted by going through various literature. They must exclude the quick tensile tests. In regard to the critical scaling temperature, the actual scaling temperature of a 17.7 chromium, 8 nickel alloy, as determined from Dr. Hatfield's figure, was placed at 900 deg. C. In practice he (Mr. Kayser) came to the conclusion that it was between 850 and 900 deg. C., and he agreed that he would not use that alloy above 800 deg. They must have a factor of safety and it must be about 100 deg. C. If only the thinnest possible layer of skin was raised over the scaling temperature that surface would scale.

In regard to the effect of chromium on cast iron, Mr. Kayser said that if they started with a steel containing 1½ per cent. of carbon, they knew how it behaved in forge and foundry and how it machined when annealed. Commencing adding chromium to that—5, 10, 15 per cent. and upwards—they would find that the first increase of chromium tended to harden it, but when they got to about 15 per cent. the metal became readily malleable. Continuing with their addition of chromium, at about 20 per cent., they found the metal fairly unworkable. But when they exceeded a critical percentage of chromium —25 to 27 per cent.—they suddenly got a metal easily rolled and readily machined, and 28 per cent. chromium could be rolled out into 18-grade sheets. Moreover, it was readily machinable.

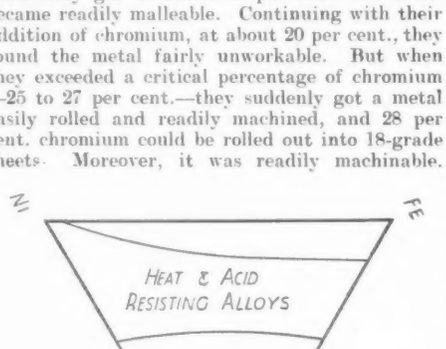


Fig. 1.

At high temperatures these chromium alloys were not brittle, but they were not suitable for lead, and, generally speaking, he did not think that any pot could be said to withstand lead at such temperatures, although, in spite of that fact, he did think it was a commercial proposition to make lead pots from heat-resisting alloys. They might put half-a-dozen into commission at temperatures not higher than 900 deg. C. and find them economical, but they might put one into commission and find it fail very quickly indeed. The lead had a most peculiar action on them, and so had salt. It was well worth while to have lead pots made from heat-resisting metal, but he did not advise alloys high in nickel for that purpose. When he talked about "the best alloy," he meant the best for one purpose and not for all purposes.

A vote of thanks to Mr. Kayser was proposed by Mr. A. Whiteley and seconded by Dr. J. G. A. Skerl. Dr. Skerl remarked that he had been struck particularly by the fact that good stainless steel castings could be made in any type of sand. He knew that to be the truth.

Metropolitan-Vickers Electrical Company, Limited.

In the course of a review of their activities in the past year, the Metropolitan-Vickers Electrical Company, Limited, point out that during the year they received from the London Power Company an order for a turbo-alternator set with condensing plant that will be the largest yet installed in Europe and actually 40 per cent. larger than any set yet built in England. This set is of 105,000 kw. maximum continuous rating running at 1,500 r.p.m. and is of the three-cylinder type.

According to Mr. W. Killingbeck, commercial manager of the Barrow Hematite Steel Company, Limited, Barrow-in-Furness, the outlook for the town as regards orders for iron and steel is bright. The firm, he states, hopes to share in the orders which will be placed shortly by the principal railway companies, which are embarking on large improvement schemes.

The Addition of Non-Ferrous Metals to Cast Iron.

(*Continued from page* 22.)

than is generally supposed. For example, many brands of Continental pig-irons contain as much as 0.75 per cent. copper, and the author has encountered frequently castings containing this amount of copper. When it is considered that the maximum amount of this element capable of being dissolved in ordinary cast iron is only somewhere between 3 and 4 per cent., this amount of 0.75 per cent. can be considered to be quite a substantial amount. This solubility of copper in cast iron alloys is influenced very much by the presence of other elements. For example, with the presence of 12 to 15 per cent. nickel, as much as 6 to 7 per cent. copper is readily dissolved, and actually an alloy containing these proportions of these two elements is one of the most important of the austenitic cast irons, and for this reason is probably the most important example of the addition of copper to cast iron.

Most investigators agree that the influence of copper additions resemble in many respects those of nickel additions, and the author's own investigations appear to substantiate this view. In a private communication with his friend, Mr. R. S. McPherran, of The Allis Chalmers Manu-

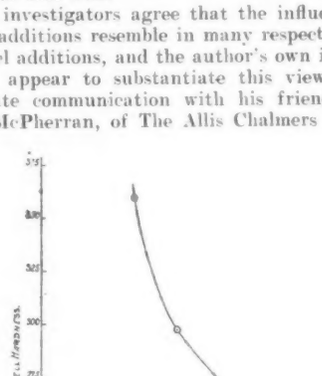


Fig. 5.—Influence of Copper on Brinell Hardness of Cast Iron.

facturing Company, U.S.A., the author has received further confirmation of this view, and is indebted to him for a photograph (Fig. 4) of a micro-specimen of a high test copper alloy cast iron showing a tensile strength of over 30 tons per sq. in. The author has studied the influence of copper additions in conjunction with chromium, with particular reference to their effect on the hardening and tempering properties. Full detailed results are to be found in the Paper above mentioned, but it is of interest to reproduce here the curve (Fig. 5) showing the relation between the Brinell hardness and copper content of the copper chromium cast irons containing T.C. 3.25, silicon 2.00, manganese 0.65, phosphorus 0.58, and chromium 0.60 per cent. This shows an approximately regular influence of copper in reducing the hardening effect of the chromium.

In view of this resemblance between copper and nickel it is probable that the greatest value of copper additions to cast iron lies in their use as a diluent of the more expensive nickel additions. For many purposes copper is perfectly satisfactory in this respect, and equal parts or proportions of 2 per cent. nickel and 1 per cent. copper can be used to replace equivalent total nickel additions.

Plain copper alloy cast irons are used direct for motor cylinder manufacture, and a 2 per cent. copper cast iron is recommended frequently for use under mild corrosion conditions. Improvements in corrosion resistance under various conditions of up to 25 per cent. have been reported in the case of certain copper cast irons.

(*To be concluded.*)

Photomicrographs and Their Interpretation.

A SERVANT OF INDUSTRY.

The East Midlands Branch of the Institute of British Foundrymen held a meeting at Loughborough College on November 18, 1933, when a lecture was given by Dr. A. Bramley, of Loughborough, on "Photomicrographs and their Interpretation." Mr. P. A. Russell presided.

DR. BRAMLEY said he had called to mind a Paper he had given a few years ago when it was suggested that more information on photomicrographs was desirable, so he intended to try to show by a few experiments and lantern slides the elementary principles of the subject. Photomicrographs, he said, could not tell all there was to be known about a metal and would not replace chemical analysis; but, on the other hand, chemical analysis did not tell all, as it did not show how elements were combined or distributed and that was what the microscope could do.

Referring to the preparation of the specimen, Dr. Bramley said that in selecting a specimen regard should be taken to the direction of that metal, as results may be different when taken lengthwise or crosswise. The polishing of the specimen was very simple, but must be done carefully. Emery cloth and emery papers should be spread and pasted on to a flat surface, preferably a sheet of glass. The specimen is then taken and rubbed on the fine emery cloth in one direction with a backwards and forwards motion until all scratches on the face of the specimen are in the direction of the rubbing. Then turn the specimen at right angles and proceed to rub as before with a No. 0 emery paper, until all scratches are in the direction of rubbing. The process is then repeated on No. 00 and 000 emery papers, reversing the direction of the rubbing on each grade of paper. When using the emery cloth care should be taken not to rub too vigorously, or one might get some bits of emery embedded into the face of the specimen, which would remain there, and may be mistaken for something else when examined under the microscope. When the finest grade of paper has been used, proceed to polish the specimen with a cloth and some powder until the specimen has a mirror finish. Dr. Bramley preferred ordinary chamois leather and jewellers' rouge mixed to a paste with a little water, the specimen being rubbed round and round in a circular motion until no scratches were left. Sometimes a pattern would be visible on the specimen, but generally there would be no pattern until the specimen had been etched.

Etching.

For etching iron and steel he used a solution of picric acid or nitric acid, and, he said, there was less liability of overdoing it with the picric acid. The amount of etching required depended on circumstances. Other etching agents could be used, such as copper solutions and hydrofluoric acid. The etching agent attacked the metal in some parts more than in others and thus showed up the pattern. Dr. Bramley then illustrated by experiment how the acid attacked one metal more vigorously than another. Why did this happen? Imagine, he said, a molten metal solidifying, when crystallisation began, and impurities tended to segregate to the parts that solidified last. The more impure the metal, the more readily would the acid attack. Due regard should be taken of the magnification to be used and notice of how rapidly the metal etched and useful deductions could be drawn. If one wished to compare micro sections of two cast irons and the sections were not at the same magnification, wrong conclusions might be drawn. With regard to the time of etching, that depended on what one wished to see. For a magnification of 100, one would etch for a limited time, but if the magnification of 1,000 was called for, it should only have a much lighter etching. During the process of etching, the acid was eating away some part of the specimen and making the surface rough and one might focus the microscope correctly on one level and be out of focus on another, and when examining at a high magnification the limit of accuracy of adjustment was very fine indeed, so only a light etching was needed. Dr. Bramley then proceeded to explain photomicrographs of all types of metals at varying degrees of magnification which illustrated all the points mentioned.

DISCUSSION.

MR. A. E. PEACE said he thought Dr. Bramley might have stressed the examination of unetched specimens. He realised Dr. Bramley was in some difficulty, as his audience was almost entirely interested in cast metals and not in wrought material. In the examination of any cast metal he found it necessary to examine first an unetched specimen. It was desirable to search for slag inclusions and flaws that could be detected before etching. Etched specimens were very complex and flaws might be overlooked. In connection with the crystal boundaries, Dr. Bramley had referred to the unanswered problem of whether there was nothing between the crystals or an amorphous metal, and he (Mr. Peace) thought there must be something between the crystals. Metals subjected to a shock sometimes broke through the crystals and not around the crystal boundaries, showing they have greater strength than the crystals. In cast iron it was impossible to bring the whole structure into focus, and graphite, or holes where graphite had been, were naturally out of focus. He had never encountered Neumann lines in cast metals, and he would like to know if their occurrence was confined to wrought metals. He had greatly enjoyed Dr. Bramley's lecture, and he complimented him in covering such a wide subject in such a general way.

DR. BRAMLEY said he quite realised there was much to be done on unetched specimens. He thought there was some matter in the crystalline boundaries, because the finer the crystals, the stronger the metal. Inter-granular fracture was generally the result of some chemical attack. He had never seen Neumann lines in cast metals.

MR. S. H. RUSSELL, referring to Dr. Bramley's remarks on phosphorus in steel and cast iron, said it was dangerous to draw an analogy between the strength of steel and cast irons. Conditions were very different in cast irons. It was easy for pouring temperature to be too high in special bronzes, and the microscope would show whether trouble was due to hot pouring. Dr. Bramley had shown the presence of sulphur as small grey patches, and these were allied with manganese. If no manganese were present, what form would the sulphur be then?

DR. BRAMLEY said the presence of sulphur in the absence of manganese caused the steel to be what is known as a "red short," and would break off as soon as the smith gave it a blow whilst hot. If sulphur were present, the manganese would rob the iron of its sulphur and produce manganese-sulphide. Manganese-sulphide is less detrimental than iron-sulphide. The freezing point of manganese-sulphide was 1,589 deg. and iron-sulphide 1,128 deg. C., so the last to solidify was the iron-sulphide, and it entered the crystal boundaries. When such steel was hot, the sulphide would melt and cause it to break through the crystal boundaries. If manganese were added, the first part to solidify was the manganese-sulphide, and the crystals grow around it and the intercrystalline metal was strong. The amount of manganese should be three or four times the sulphur. If too much manganese were added, it had a detrimental effect, but up to 0.5 per cent. it was beneficial.

A MEMBER referred to the fact that Dr. Bramley had not mentioned heat-tinting.

DR. BRAMLEY replied that heat tinting was very useful. For instance, it would show up phosphorus.

MR. DRIVER, referring to the founder in a small business, asked whether Dr. Bramley would recommend anything in the way of a simple microscope to be used in the small foundry, and if such an instrument was installed, to what extent would it be valuable to the skilled foundryman, who was not necessarily a skilled chemist?

DR. BRAMLEY said he did not think it necessary to spend much money, but if high magnifications were required it would be necessary to buy expensive instruments. For a figure around £10 one could buy a new microscope suitable up to 300 or 400 magnification. The foundryman could see what he wanted without photomicrographs. Even if photographs were required the apparatus need not be expensive. The lenses were all in the microscope, and the camera need only be a box arrangement to hold the plate. The ordinary foundryman should find a simple apparatus very useful indeed.

The BRANCH-PRESIDENT (Mr. P. A. Russell) said the microscope had become an essential feature in heat-treatment practice, and it was rapidly occupying a similar place in the foundry. More and more would photomicrographs be used by lecturers to illustrate their Papers, and with that in view the Institute's Technical Committee would shortly be issuing a booklet on this subject but confined to cast irons.

MR. STEVENSON proposed, and MR. PEACE seconded, the vote of thanks to Dr. Bramley for a very valuable and instructive address.

Activities of the General Electric Company, Limited.

During the past twelve months the General Electric Company, Limited, have been responsible for much important work, and many industrial schemes have been carried out. Several rolling-mill motors are being built by the firm for the Whitehead Iron & Steel Company, Limited, Monmouthshire, and also for I.C.I. Metals, Limited. A further rolling-mill motor is being constructed for a steelworks in Rumania. A G.E.C. Fraser & Chalmers winder has just been completed for the Champion Reef Gold Mine, Southern India. The weight of ore per wind is 5,300 lbs., depth of wind 3,633 ft., and speed of wind 1,910 ft. per minute. The electric motor is a direct-current machine of 1,150 h.p. capacity at a speed of 37.5 r.p.m., and is direct coupled to the winder. Much experimental work has been carried out in connection with explosion-proof motors and switchgear, and several G.E.C. machines, switches, etc., have been designed and tested at Buxton, gaining the certificates issued by the Mines Department (Testing Section), known as "Buxton Certificates." An interesting control scheme has recently been prepared, and the apparatus manufactured, for the South African Iron & Steel Industrial Corporation, who purchase some of their power in bulk from Pretoria muncipality and generate some in their own power station at Iscor. This scheme involves the control of the turbo sets in the Iscor power station so that the power drawn from the Pretoria station is as far as possible constant in magnitude and supplied at unity power factor. The whole of the apparatus is automatic in action. Important railway electrification schemes have been completed for the L.M.S. Railway Company and the Metropolitan Railway.

A COMPANY, TO BE CALLED Worldwin Pistons, Limited, is to be formed with a capital of £11,000 for the erection of piston-making works at Cyfarthfa, Merthyr, alongside the plant of the Aye-deecee Metals (Parent) Company, Limited. Aye-deecee aluminium alloys will be used in the new undertaking.

Newcastle and District Branch of the Institute of British Foundrymen.

At the opening meeting of the Newcastle and District Branch of the Institute of British Foundrymen the Presidential Address was delivered by Mr. J. D. Carmichael, O.B.E., the newly-elected President. After the Presidential Address a film, entitled "The Building of the Sydney Harbour Bridge," was exhibited, by kind permission of Messrs. Dorman, Long & Company, Limited. Mr. Fred Osborne, an official of the company who was present at the building of the bridge, explained the various details of the film. About 150 were present, including members of kindred societies.

In opening the meeting, Mr. Carmichael said that his first duty was to propose a hearty vote of thanks to the retiring President, Mr. Scott, and to ask him to accept their grateful thanks for guiding the destinies of the Branch through the past year, which had been a very difficult one. After the vote of thanks had been passed, Mr. Carmichael, in the course of his address, said that it was fifteen years since his late father occupied the Presidential chair, and he hoped to follow in his father's footsteps, so that at the end of his year of office he would meet with their approval. The apparent lack of interest shown by members during the last session had prompted his address, and he wanted every individual member, if possible, to renew the enthusiasm of the old standards, so that the Newcastle Branch might once again take its rightful place as one of the leading branches of the Institute.

A Golfing Parallel.

There were three things which made a young man, ambitious of rising above the artisan class, of value to an employer: good workmanship, expert knowledge of the business, and looking after the business first and himself secondly. It was not possible to do a job well while thinking of something else. In golf one had to keep one's eye on the ball, and in life on the object. A commercial traveller might be told to get a certain order, but instead of continuing with absolute determination, he tries only sufficiently hard to salve his conscience, without achieving his object. The employer who gave the instruction did not give it for the man's peace of mind; it did not occur to him that conscience came into it. He has his eye on the object, and all he asks is that his employee should similarly have his eye on the object. Those who had formed the habit of remaining satisfied, not with achievement but with a quiet conscience, should quit thinking about their conscience and do their work with a single mind to do well. There were two classes of labourer whose weeks consisted of 160 hours divided into shifts—the blast-furnace man and the seaman. They could calculate what the price of pig-iron would be if the blast furnaces were shut down, or the cost of transport if the ship hove to, at 5 p.m. every night until 7.30 a.m. the next morning. Yet the same ship reverted to those hours for dockers, ship repairers and other workers.

All the great discoveries since the time of primitive man had been made by men who were actuated simply by the desire to know, men who had kept their eyes on their object. Who was there present who would not wish to be, perhaps, a benefactor of mankind, a James Watt or a Faraday? Let them see that the flame did not die out, because when it died the springs of human progress would have disappeared. In other words, let them keep their eyes on the object. Opportunity was surely unlimited for those men, who could do their job but who had not had the education to make them not only conversant with the practical side but with the scientific side also, to obtain the necessary education. He anticipated that in the future when their industry became more intricate the directing minds would be drawn from the group who had a thorough technical as well as practical training.

Regarding the technical education of members of their profession, what were they going to do about it? Their industrial future depended upon their technical advancement. It was fatal to think that every job that they turned out was the best they could do. Professional workers as well as mechanics had to expect to have to retrain. When every foundry in the district was suffering from a lack of orders they could only consider the question in the light of normal times. There seemed to be a controversy between the advocates of workshops and schools as to the correct training ground for foundry workers. Training for heavy foundry work could not be obtained in a school. What was needed was practical training combined with technical training at evening schools. They always had to remember that the apprentice was entitled to receive personal assistance from his employer, without which all the technical education in the world would be of little avail, as the boy would revert to the age-old methods used by his grandfather. The John Surtees Memorial Fund had been founded to provide medals and prizes for the Institute. It was regrettable to recall that the gold medal offered in the Senior Division had never been competed for. It must be obvious that the Surtees silver or gold medal would be of value in the present time of unemployment to a young man wanting work. Any officers of the Branch would be very happy to render any assistance required to apprentices who wished to enter for that competition.

Mr. Carmichael also mentioned the work of the British Cast Iron Research Association and the Non-Ferrous Association. He reminded them that these Associations kept their members in touch with their work and issued quarterly extracts from important Papers given in all parts of the world. How could foundrymen take advantage of that without technical training? He therefore appealed to them for greater interest in the affairs of the Branch by their attendance at and personal interest in the meetings. Various lectures were given throughout the session which were the personal experience or research of the lecturer. Unfortunately during the past session much valuable information had been given to empty benches.

It was 21 years ago since he joined the Institute at the time when the Newcastle Branch was first founded. He could not recall a more anxious period for foundrymen than the present industrial depression. How many foundries on Tyneside were training apprentices and where were the skilled operatives of the future to come from?

He had tried to avoid controversial subjects in his remarks, but he hoped to help the future of the industry and hoped also that they would determine to give of their best, whether to employer, customer or to the Institute to which they were all proud to belong.

At the conclusion of Mr. Carmichael's address, Mr. C. Gresty said that before continuing with the other business of the meeting he would like to propose a hearty vote of thanks to the President for his address, which had been a very thoughtful one, and although there was to be no discussion, he would like, as proposer of the vote of thanks, to add a little to what Mr. Carmichael had said on the question of education. He had stressed the great need of it, but the difficulty was to arouse the enthusiasm of the younger members. Three or four years ago Rutherford Technical College had taken up the serious matter of training apprentices, and established a foundry in Newcastle for that purpose, in conjunction with other classes. The experiment had proved very successful the first year, but there had been a serious lack of enthusiasm in succeeding years. If any of those present had any influence with boys in the foundry, would they just remind them of when the classes commenced each September, as there was a doubt as to whether the educational authorities would think it worth while keeping the classes going.

Patent Specifications Accepted.

The following list of Patent Specifications accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

21,982. WILTSHIRE, W. F. Lid or cover for melting furnaces. 401,629.

17,426. DORMAN, LONG & COMPANY, LIMITED, and JUDGE, E. T. Welding. 401,614.

27,712. HERAEUS-VACUUMSCHMELZE AKT.-GES. Production of substantially carbon-free alloys. 401,094.

410. WOLFRAM & MOLYBDAEN AKT.-GES. Process for producing pressed shaped pieces of hard metal. 401,521.

Kogag Coke Ovens.

Messrs. Gibbons Bros., Limited, Dibdale Works, Dudley, have recently received from the Cargo Fleet Iron Company, Limited, an order for a further 22 Kogag coke ovens, making the Kogag plant at these works the largest individual unit in Great Britain. The ovens are fired either by oven gas or blast-furnace gas, as desired, and the materials for the new installation will be entirely fabricated at the works of Messrs. Gibbons Bros.

Stainless-Clad Steels.—According to E. C. KREUTZBERG in "Steel," the Ingersoll Steel & Disc Company, Chicago, after extensive experimentation, has announced the development of a stainless-clad material, known as "Ingoclad," produced by a process which assures a bond between the stainless surface and the base metal. The company now is rolling this material in sheets and plates in commercial gauges, lengths and widths. More recently it started fabricating the material into barrels with stainless-clad linings. Strip has also been produced successfully as light as 0.025 in. The clad material will shortly also be marketed in the form of rolled and spiral-welded pipe, wherein the stainless surface may be either on the inside or the outside of the pipe as desired. The company has developed a special technique for both production and fabrication of stainless clad. Two ground, stainless steel plate inserts with a layer of insulating material between them are joined together by an unbroken weld entirely around their four sides. This insert is then placed in an ingot mould and held in correct position. When the hot, mild steel is poured into the mould it completely envelops the stainless inserts. After the rolling operation is completed, the sides and ends of the rolled product are sheared, which results in two plates each one-half the thickness of the rolled plate. By this process of sealing the stainless inserts there is no possible chance for scale to appear inasmuch as air and oxygen are completely eliminated, therefore, an unusually clean surface is obtained.

ON DECEMBER 30, 1933, Messrs. J. & J. Dyson, Limited, of Stannington, entertained over 200 employees of the firm at a dinner held at Cockayne's Restaurant, Sheffield. The event was much appreciated by the workmen, who for some considerable time have been working at high pressure in order to cope with the rapidly-increasing business of the firm.

This Week's News in Brief.

Trade Talk.

THE CLAY CROSS COMPANY, LIMITED, Chesterfield, has installed a concrete lining plant for cast-iron pipes, which are specially suited for use for water mains when undue incrustation is likely to occur.

MESSRS. SCOTT & SONS, LIMITED, Bowling, have received an order from Irish owners to build two coastal steamers. The vessels will each be 150 ft. in length, and will incorporate all recent improvements in cargo-boat construction.

GLASGOW CORPORATION LIGHTING DEPARTMENT is to experiment with aluminium-alloy-casting lanterns instead of the normal iron lanterns at present in use. If the experiment is successful, aluminium lanterns will gradually be adopted throughout the city. These lanterns, the first of their kind in Scotland, cost 15s. more than iron lanterns.

MESSRS. HARRISON & COMPANY (LINCOLN), LIMITED, are installing a second Stein oil-fired rotary melting furnace in their foundry as a result of their experience with the Stein rotary furnace, put in by Stein & Atkinson, Limited, during last year. It is understood that provision is being made in the lay-out for future furnaces.

THE EMPLOYEES of the following firms have allocated sums from charities and benevolent funds for the past year:—Works and offices of Stewarts and Lloyds, Limited, Glasgow, £3,417; William Baird & Company, Limited, Glasgow, £2,542; Messrs. D. & J. Tullis, Limited, Kilbowie Iron Works, £200; Messrs. Watson Laidlaw & Company, Limited, Glasgow, £143.

BY THE ENTERPRISE of the directors of Henry Balfour & Company, Limited, a new factory is being built on 2½ acres of ground at Leven for the purpose of manufacturing the products of the Enamelled Metal Products Corporation (1933), Limited, a company which has been brought into being as a result of negotiations between Messrs. Balfour and Messrs. Pfaulder, Limited, of the United States.

THE COLVILLE CONSTRUCTION COMPANY, LIMITED, a subsidiary company of Colvilles, Limited, has been successful in securing further important contracts for structural steel work for the remaining section in the rebuilding of the Bank of England. The company has already executed a contract for one of the previous sections. The contract now fixed will require about 7,000 tons of steel. The steel will be principally produced at the Glengarnock Works, but a portion will be manufactured at Motherwell Works.

THE LEITH-BUILT motor coasting vessel, "British Coast," has completed most successful trials in spite of high winds and heavy water. The ship, which represents an important development in the coastal trade of the country, exceeded the highest expectations of the builders and owners. She exceeded her contract speed by over a knot and revealed exceptional steadiness. The vessel is engined with Atlas Diesel engines and has a fuel oil capacity for a month's normal working. The ship was built by Messrs. Henry Robb, Limited, for Coast Lines, Limited.

ALL THE FORMER EMPLOYEES of Messrs. Stewarts and Lloyds, Limited, Clydesdale Steel Works, Bellshill and Mossend, will have their present recreation facilities continued for at least another year. This is good news to the 700 men who were thrown idle with the closing of the universal plate mill. The Clydesdale recreation facilities are extensive, including the Carfin Hall, bowling greens, cricket field, tennis courts, football field and a large works institute.

MESSRS. C. F. WILSON & COMPANY (1932), LIMITED, Constitution Street, Aberdeen, have completed the second of what they claim to be the largest horizontal Diesel oil engines made in Scotland. The engines are twin-cylinder and measure 12 ft. by 12 ft. by 7 ft. high, inclusive of flywheel. They are of 120-130 h.p. and weigh 10 tons each. The first engine went to a factory in Bombay, where it replaced a steam engine, and the second is going to a factory in Middlesex.

PROGRESS IS BEING MADE by the International Baths Association, which was formed to protect the industry against unreasonable competition. Mr. G. H. Berry, the Controller, has received a very satisfactory backing on the construction of the new merchant list on the basis of the application which was distributed. It is proposed to launch a nation-wide advertising campaign, and steps are being taken to select a suitable agent for the purpose. The campaign will be under headway before the spring.

THE INDUSTRIAL WELFARE SOCIETY has arranged to hold the 12th Annual Conference for Editors of Works and Staff Magazines on February 16, 1934, in London. The Conference will open with luncheon, at which Sir Robert Waley Cohen, K.B.E., will be the guest. Two Papers will be read during the afternoon and will be followed by discussion. While the Society is in touch with about 250 of these journals, it is anxious to bring this conference to the notice of all firms publishing such magazines. Further details may be had from the secretary, 51, Palace Street, S.W.1.

THE FIRST SOD was cut on Thursday for the big extensions, covering more than three acres, at the works of Ley's Malleable Castings Company, Limited, Derby. The oldest and the youngest employees took part in the interesting little ceremony. The sod was turned by Mr. George Ford, of Albion Place, Derby, a patternmaker, who has been with the firm for 51 years, and the first spadeful of earth was dug by one of the youngest boys employed by the firm. The sod was cut in the centre of what will be a new foundry on land which has been bought from the L.M.S. Railway Company. It is anticipated that between 400 and 500 extra employees will be engaged when the foundry is opened.

Contracts Open.

Belfast, January 18.—Iron and steel stores, for the Corporation. The City Surveyor (Room 83), City Hall.

Richmond, January 20.—1,000 yds. of 6-in. vertically-cast iron pipes and specials, for the Town Council. Mr. W. W. Foster, town clerk, Richmond, Yorks.

Belfast, January 18.—1,300 ft. of 6-in., 7-in., 8-in. and 9-in. dia. cast-iron or centrifugally-spun iron pipes and specials, for the Corporation. The City Surveyor's Department (Engineering Section), Room 94, City Hall, Belfast.

Belfast, January 23.—Iron and steel stores, for the Tramways Committee. The General Manager, Corporation Tramways Department, Sandy Row, Belfast.

Blackpool, January 22.—Iron and steel stores, for the various departments of the Corporation. The Borough Treasurer, Town Hall, Blackpool.

New Mills, January 20.—(*a*) Electrically-driven pump, capable of pumping 12,000 gallons of water per hour; and (*b*) electrically-driven water boosting plant, for the Urban District Council. Mr. J. S. Brown, engineer and general manager. Gas and Water Office, Gasworks, New Mills, near Stockport.

New Companies.

Alloy Pistons, Limited, 56 & 58, Rochester Place, Camden Town, London, N.W.—Capital £3,000. Directors: C. M. White and G. H. Anderson.

Wigston Foundry (1934), Limited, South Wigston, Leics.—Capital £5,000. Directors: W. R. Bates, A. Mason, J. B. Lowthian, T. T. Sawday and G. Barrett.

J. Gray & Sons, Limited, 5, Victoria Street, London, S.W.1.—Capital £2,000. To take over the business of consulting furnace and enamelling engineers, etc., carried on as "Jas. Gray & Sons." Directors: J. T. Gray and Elizabeth E. Gray.

General Constructional & Engineering Company (Bedford & Son), Limited, Hutchings Street, West Ferry Road, Millwall, London, E.—Capital £2,000. To take over the business of a constructional engineer carried on by W. B. Bedford at Millwall, London, E., and to acquire an agreement between the General Iron Foundry Company, Limited, and W. B. Bedford. Directors: W. B. Bedford and S. J. Bedford.

Company Reports.

Qualcast, Limited.—Interim dividend on the ordinary shares of 5 per cent., less tax.

Ferranti, Limited.—Dividend on the 7 per cent. cumulative preference shares for the half-year to December 31.

Personal.

MR. WILLIAM ROBERTSON, of New Grange Foundry, Bo'ness, has been presented with a watch to mark the completion of 52 years' service.

SIR WILLIAM FIRTH (chairman of Messrs. Richard Thomas & Company, Limited) has been elected chairman of the Management Committee of the London Iron and Steel Exchange.

MR. ARNOLD GRAVES, A.S.A.A., incorporated accountant, has been appointed secretary to Messrs. J. & J. Dyson, Limited, of Stannington and Sheffield, in succession to Mr. W. C. Brameld, who has now retired.

THE ANNUAL TREAT to the children of the employees of Messrs. John G. Stein & Company, Limited, Bonnybridge, was given in the Works Canteen on December 30. Mr. Charles Taylor presided, and after tea an entertainment was given by the children.

MR. AND MRS. ALEXANDER STEPHEN, of Roslin Street, Aberdeen, have celebrated their golden wedding. Prior to his retirement a few years ago, Mr. Stephen was employed for over 30 years in the foundry of Messrs. Thomson & Stewart, Limited, King Street, Aberdeen

THE SIXTIETH ANNIVERSARY of their wedding was celebrated last week by Mr. and Mrs. John Smith, of Hamilton, who are 80 and 82 years old respectively. Mr. Smith was for 49 years employed as a furnaceman at Messrs. Frew's Fullwood Foundry, Hamilton, commencing employment under the originators of the firm and retiring about eight years ago.

AMONGST THE New Year Honours is Mr. Alexander Ferguson, the former Welfare Supervisor of Messrs. Glenfield & Kennedy, Limited, Kilmarnock, who has received the M.B.E. Mr. Ferguson is now senior assistant secretary in the Scottish Juvenile Welfare and After-Care Office, Edinburgh. During the war he served in the Royal Air Force and was awarded the Military Medal.

MR. AND MRS. THOMAS STRUTHERS, of Falkirk, have celebrated the fiftieth anniversary of their marriage. Mr. Struthers was for 28 years employed as a pattern moulder in the Grahamston Iron Company's foundry in Falkirk, after which he went to England for a time, later returning to become foreman pattern moulder with Messrs. Gillespies, Limited, Bonnybridge, until he retired.

Will.

HUNTER, ADAM, civil engineer and late managing director of Sir William Arrol, Limited £22,314

Obituary.

MR. JOHN BRIGHT HOBLYN, A.R.C.S., chief metallurgist of Vauxhall Motors, Limited, died recently. As a lecturer, Mr. Hoblyn was amongst the most popular in scientific circles.

THE DEATH HAS OCCURRED, at his home at Grassington, of Mr. Fred Stanley Clayton, head of M. Clayton & Son, brassfounders, of 310, Wakefield Road, Bradford, an undertaking established in 1870 by his father, Mr. Mark Clayton. Mr. F. S. Clayton was 62 years of age.

COLONEL HENRY HOWARD, of "Stone House," Kidderminster, died last week at the age of 85. He was a director of Messrs. Stewarts and Lloyds. In 1868, with the late Mr. C. S. Lloyd (chairman of Lloyds Bank), he purchased Coombs Wood tube works, and later there was a combination with the Glasgow firm of Stewarts & Menzies.

THE DEATH OCCURRED last week of Mr. David Robert M'Neill, of Corrie, Four Oaks, Warwickshire, in a nursing home at Sutton Coldfield. Mr. M'Neill was well-known in the Falkirk ironfounding industry, having served for many years with the Carron Company, and some years ago transferred his services to the Eagle Foundry of Messrs. John Wright & Company, Birmingham, where he was appointed manager.

MR. HERBERT CATCHPOLE, of Messrs. J. & J. Dyson, Limited, Stannington and Sheffield, died on January 2, 1934. As manager of the builders' merchant department of the firm at Union Lane, Sheffield, Mr. Catchpole was a notable figure in the Sheffield building trade, and had been associated with the firm for over 40 years. He was Past-President of the Sheffield Builders Merchants' Association, and had frequently represented the Association at meetings and conferences throughout the country.

XUM

Raw Material Markets.

The pig-iron markets retain a firm tone, although new business is necessarily limited, as many consumers are already covered by contracts. The producers continue to be very active, and it is expected that three additional furnaces will be in operation in the Cleveland area by the end of the month. No alterations have yet been made in quotations, although changes have been expected for some time, in view of the increasing cost of raw material.

Pig-Iron.

MIDDLESBROUGH.—The Cleveland pig-iron market is in an exceptionally strong position. The consuming works have been very busy and there was little or no check in deliveries of iron over the New Year. There is a ready demand for any supplies of iron available, but nearly all of the makers' output for the next three months is already sold. The two blast furnaces to be started at Redcar are to produce only steelworks iron, but the furnace being relit at Skinningrove will make Cleveland iron, thus helping to relieve the shortage. A rise has been expected in quotations for some time. In the meantime only small prompt lots of No. 3 Cleveland G.M.B. can be picked up at the old prices, which are 62s. 6d. per ton delivered Middlesbrough, 64s. 6d. delivered North-East Coast, 62s. 3d. delivered Falkirk and 65s. 3d. delivered Glasgow. For No. 1 quality 2s. 6d. per ton is added to the above prices and 1s. is deducted for No. 4 foundry and No. 4 forge.

The home demand for East Coast hematite remains very strong, and the restarting of more productive plant would be justified. The makers' stocks are considerably reduced, and in some cases every ton of iron on the ground has been sold. The makers are unwilling to enter into forward contracts at the present nominal quotations, which, for mixed numbers, are 62s. 6d. f.o.r. makers' works, and for export sales 60s. per ton f.o.b. There is little necessity, however, for the makers to accept the lower return offered by export business.

LANCASHIRE.—There has been little new business since the resumption, as many consumers covered their requirements in the buying movement which ended just before the holidays. The call for deliveries of iron shows that many Lancashire consumers have started off the New Year actively. Busy conditions are reported from a number of specialty engineering works, while the light-castings trade generally remains active. Pig-iron prices continue firm, with Derbyshire, Staffordshire and North-East Coast brands of No. 3 all on offer for delivery to users in the Manchester zone on the basis of 67s. per ton, Northamptonshire at 65s. 6d., Derbyshire forge at 62s., Scottish foundry at from 79s. to 80s., East Coast hematite at about 76s. 6d. and West Coast hematite at 80s. 6d. Cheap offers of Indian pig-iron continue to be reported, and are hampering to some extent the movement of Scottish and other brands in Lancashire.

MIDLANDS.—Consumption of pig-iron in the Midlands is maintained at the high level reached in December, and, indeed, shows signs of expansion in one or two directions. It had been thought that an increase in makers' quotations might be seen this month. However, for the time being the Association minimum figures are 62s. 6d. for Northants No. 3 and 66s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, including delivery to Birmingham and Black Country stations, with 7d. per ton extra for delivery into consumers' works. There continues to be a fair call for special irons for the engineering trade and for motor-car and engine work. No. 3 Scottish foundry iron is quoted at 85s. per ton, other low-phosphorus pig from 80s. to 90s. per ton, and medium-phosphorus iron from 70s. to 80s. Where refined iron to guaranteed analysis is required the price varies from £5 15s. to £6 15s. per ton.

SCOTLAND.—There is little new business being done in Scottish pig-iron, quotations remaining at 65s. f.o.t. furnaces, with 2s. 6d. per ton extra for No. 1 quality. The light-castings trade continues to be very busy, and only a limited holiday was taken last week. Quotations for Cleveland iron are still at 62s. 3d. f.o.t. Falkirk and 65s. 3d. f.o.t. Glasgow. Other English irons are at 1s. 3d. per ton below these prices.

Coke.

Only a limited business is being done in the foundry-coke market at the moment, many consumers having covered themselves last year, in anticipation of a general rise in prices. So far, the latter has not occurred. Quotations, delivered in the South Staffordshire area, remain as follow:—Durham coke, 34s. to 38s., according to quality; Welsh coke, 32s. to 45s.; special Scottish coke, 38s. 6d. to 39s. per ton.

Steel.

The volume of business available in the steel markets is gradually increasing, and it is anticipated that by the end of the month it will equal, if not surpass, that for December. Business in the semi-finished steel department has been quiet; but the producers have good orders in hand and in some cases extended periods are now required for delivery. A moderate tonnage of business is being placed for Continental steel, but the recent advance in quotations has brought the Continental works' prices, including the duty, to about the same level as the British. The outlook in the finished-steel department is promising, and specifications are now reaching the steelworks as a result of the contracts placed in December. There has been an improvement in general inquiry on home account, and there seems a prospect of export business expanding in the near future.

Scrap.

In the Cleveland scrap-iron market, heavy metal is rather scarce, ordinary being quoted at 51s. and machinery at 53s. Light metal is quoted at up to 43s. per ton. In the Midlands, there is a ready sale for cast-iron scrap at about 55s. for heavy machinery, 47s. 6d. for good heavy metal and 42s. 6d. for light cast iron, all delivered works. In Scotland there is a good demand for machinery cast iron at about 53s. 6d., with ordinary cast iron at 48s. 6d. to 50s. In South Wales, however, the demand is limited and there are plentiful supplies on offer. Quotations in this district are 44s. to 48s. for heavy cast iron, 47s. 6d. to 50s. for good machinery scrap, and 38s. to 40s. for light cast-iron scrap.

Metals.

Copper.—Trading in copper has been on the dull side since the beginning of the New Year, but this is largely accounted for by recent stocktaking and repair operations at the consuming works. At the end of 1933 there was evidence of a slightly better demand for manufactured copper and brass goods, and it is hoped that this tendency will re-appear shortly. Little progress has yet been made with the scheme for placing the American copper industry under an N.R.A. code. The proposal continues to attract attention on this side, because if the proposed 9 per cent. price level is established in America, the world price should be affected, although, of course, there is the possibility of a further depreciation of the dollar to be reckoned with.

The week's prices have been as follow:—

Cash.—Thursday, £32 1s. 3d. to £32 3s. 9d.; Friday, £31 16s. 3d. to £31 17s. 6d.; Monday, £31 11s. 3d. to £31 12s. 6d.; Tuesday, £31 6s. 3d. to £31 7s. 6d.; Wednesday, £31 5s. to £31 7s. 6d.

Three Months.—Thursday, £32 5s. to £32 6s. 3d.; Friday, £32 to £32 1s. 3d.; Monday, £31 15s. to £31 16s. 3d.; Tuesday, £31 8s. 9d. to £31 10s.; Wednesday, £31 7s. 6d. to £31 10s.

Tin.—Business in tin, both in this country and on the Continent, has been only moderate, as the trade demand has not yet returned to its normal level. The London market has maintained a steady tone, in spite of slightly weaker quotations.

It was originally proposed, in connection with the international restriction of tin exports, to create a "buffer stock," to be administered by a committee, in order to rule out excessive fluctuations in market prices. Considerable opposition has been expressed to the scheme, and it is hoped that, as consumers already have to pay twice as much for their metal as they did a year or two ago, further restrictions will not be placed on the market.

Daily quotations:—

Cash.—Thursday, £224 17s. 6d. to £225; Friday, £226 2s. 6d. to £226 5s.; Monday, £224 12s. 6d. to £224 17s. 6d.; Tuesday, £224 5s. to £224 7s. 6d.; Wednesday, £224 7s. 6d. to £224 10s.

Three Months.—Thursday, £225 7s. 6d. to £225 10s.; Friday, £226 7s. 6d. to £226 10s.; Monday, £225 to £225 5s.; Tuesday, £224 7s. 6d. to £224 10s.; Wednesday, £224 12s. 6d. to £224 15s.

Spelter.—Trade demand has been quiet, both in this country and also on the Continent, where business with consumers is reported to have been on a reduced scale, with sellers at the same time showing rather more disposition to realise. The weakness is in all probability temporary and might be regarded as normal at this season of the year, for there is no apparent change in fundamental conditions governing the statistical situation, and the technical position on the London market remains sound.. In the United States of America the market is quiet, report Messrs. Rudolf Wolff & Company.

Price fluctuations:—

Ordinary.—Thursday, £14 8s. 9d.; Friday, £14 8s. 9d.; Monday, £14 3s. 9d.; Tuesday, £14 3s. 9d.; Wednesday, £14 6s. 3d.

Lead.—Although the price of lead has again fallen to a level which in normal times would be considered absurdly cheap, the presence of ample supplies is continuing to exert a depressing influence. Demand from consumers is only moderate, but purchases are gradually increasing in volume, owing to the attractive price level. The announcements which are made in America from time to time regarding the remonetisation of silver are an encouragement to those lead producers whose revenue is partially obtained from silver. The result has been a steady increase in the production of lead, which has not been absorbed, and the price has therefore fallen sharply to 4 cents, report Messrs. Brandeis, Goldschmidt.

Daily market prices:—

Soft Foreign (Prompt).—Thursday, £11; Friday, £10 17s. 6d.; Monday, £10 13s. 9d.; Tuesday, £10 17s. 6d.; Wednesday, £10 18s. 9d.

Students Corner.

Q.—What are the blast pressures desirable for cupolas of various diameters?

A.—It is admitted that a pressure gauge does not indicate the amount of blast entering the cupola; it is quite easy to obtain a high pressure without any blast entering the cupola. Any obstacles in the blast main; small or dirty tuyeres, and the like, increases the indicated pressure on the gauge, but does not indicate the volume of air entering the cupola, which is of more importance than pressure. A pressure gauge is useful when all other conditions are favourable, such as diameter of blast main, size and area of tuyeres, etc., then it is handy to show from day to day that conditions are normal or abnormal. Pressure of blast is needed to penetrate the centre of the cupola whatever may be its diameter, and the following are submitted as suitable.

Blast pressure per sq. in. in ozs. for various diameter cupolas.

Cupolas	**24 in. dia.,**	**6 ozs.**	
,,	**36** ,,	**9**	,,
,,	**48** ,,	**11**	,,
,,	**60** ,,	**13**	,,
,,	**72** ,,	**14**	,,

The best gauge is the one that registers volume of air and pressure of air, and these are now available.

Q.—What should be the tuyere area in relation to the diameter of cupola?

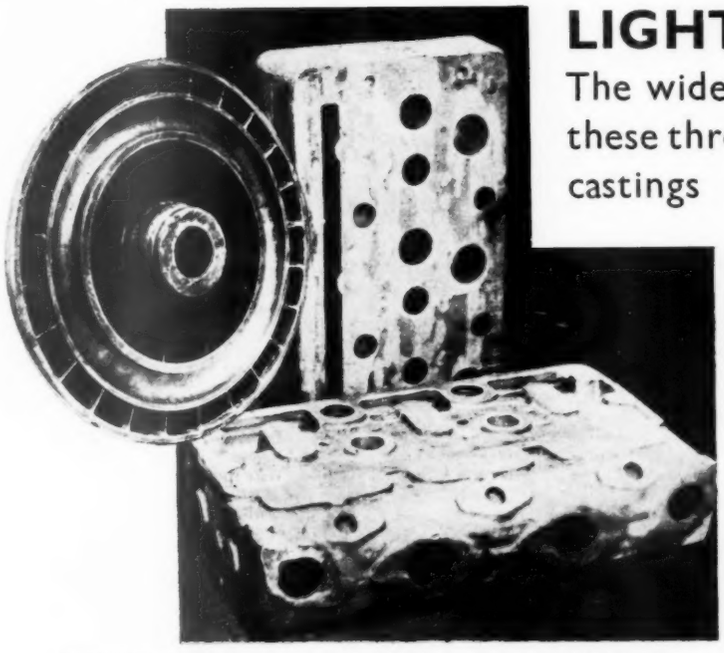
A.—Roughly the total area for various diameter cupolas is as follows:—

Cupolas	**24 in.**	**dia., tuyere area**	**100 in.**	
,,	**36**	,, ,,	**200**	,,
,,	**48**	,, ,,	**300**	,,
,,	**60**	,, ,,	**400**	,,
,,	**72**	,, ,,	**500**	,,

The size of the blast main must adequately cover the tuyere area. The above are approximate but reliable.

for HIGH THERMAL CONDUCTIVITY, LIGHTNESS *and* STRENGTH.

The wide adoption of aluminium alloys, for these three reasons, is illustrated here with castings of HIDUMINIUM R.R. ALLOY.



Left: Driving member of the Salerni fluid flywheel coupling. The approximate diameter is 18 in. and the weight 15 lbs.

Right: Cylinder head for A.E.C. high-speed oil engine. The size is 18½ in. by 10½ in. by 4½ in., and the weight 38 lbs.

(Picture by courtesy of HIGH DUTY ALLOYS, Ltd., Slough, Bucks.)

ALUMINIUM AND LIGHT ALLOYS
The BRITISH ALUMINIUM CO. Ltd.

HEAD OFFICE: ADELAIDE HOUSE, KING WILLIAM ST., LONDON, E.C.4.
TELEPHONE: MANSION HOUSE 5561 & 8074 (5 LINES) TELEGRAMS: CRYOLITE, BILGATE, LONDON

LONDON WAREHOUSE: 25-29, Pancras Rd., N.W.1.
BIRMINGHAM: Lawley St. & Landor St.
MANCHESTER: 274, Deansgate.
LEEDS: 66, Kirkstall Rd.
NEWCASTLE-ON-TYNE: Milburn House.
GLASGOW: 113, West Regent St.

The BRITISH ALUMINIUM COMPANY, Ltd.

F.T.J. 11.1.34

BRITISH REMA

Blacking Wash Mixer.

Produces 40 gallons of high grade facing material in 15 minutes.

ADVANTAGES—

Thoroughly mixed material.

Uniform mixture ensures mould faces being covered evenly.

Mixture can be drawn off as required from either tank.

Built in a wide range of sizes to suit large or small foundries.

BRITISH REMA Pulverised Fuel Firing also will interest you. Send for catalogue.

The British Rema Mfg. Co., Ltd.,
Hubert Street Works, Halifax.

LONDON REPRESENTATIVE:
P. G. Ryder, First Avenue House, High Holborn, W.C.1.

British Rema No. 1 size double tank centrifugal mixing and emulsifying machine for mixing liquids, and liquids with solids. Capacity of each tank 40 gallons. Drive by electric motor through texropes.

XUM

RAW MATERIALS—PRICE LIST.

(Wednesday, January 10, 1934.)

COPPER.

	£	s.	d.
Standard cash	31	5	0
Three months	31	7	6
Electrolytic	34	15	0
Tough	33	10	0
Best selected	34	0	0
Sheets	62	0	0
India	43	5	0
Wire bars	35	0	0
Ingot bars	35	0	0
H.C. wire rods	38	0	0
Off. av. cash, December	31	6	11 13/19
Do., 3 mths., December	31	9	5 13/19
Do., Sttlmnt., December	31	6	11 13/19
Do., Electro, December	34	14	2 10/19
Do., B.S., December	34	1	11 3/5
Do., wire bars, December	35	1	10 5/19
Solid drawn tubes			10d.
Brazed tubes			10d.
Wire			6½d.

BRASS.

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	8½d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7½d.
Wire	7½d.
Rolled metal	7d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN.

	£	s.	d.
Standard cash	224	7	6
Three months	224	12	6
English	224	15	0
Bars	226	5	0
Straits	229	0	0
Australian (nom.)	—		
Eastern	228	5	0
Banca	228	15	0
Off. av. cash, December	227	14	10 9/19
Do., 3 mths., December	227	15	7 17/19
Do., Sttlmt., December	227	14	5 15/19

SPELTER.

	£	s.	d.
Ordinary	14	6	3
Remelted	14	0	0
Hard	12	0	0
Electro 99.9	16	10	0
English	14	17	6
India	13	15	0
Zinc dust	20	0	0
Zinc ashes	3	5	0
Off. aver., December	14	16	6 3/19
Aver. spot, December	14	18	10 7/38

LEAD.

	£	s.	d.
Soft foreign ppt.	10	18	9
Empire	11	2	6
English	12	5	0
Off. average, December	11	8	7 5/19
Average spot, December	11	10	10 13/38

ALUMINIUM.

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	24	10	0
Do., V.M. ex whse.	23	5	0
Rods	28	15	0

ANTIMONY.

	£	s.	d.	£	s.	d.
English	37	10	0 to 40	0	0	
Chinese, ex-whse.				26	0	0
Crude				20	0	0

QUICKSILVER.

	£	s.	d.	£	s.	d.
Quicksilver	9	2	6 to 9	12	6	

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	6 10 0
45/50%	13 0 0
75%	18 2 6
Ferro-vanadium—	
35 50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	5/6 per lb.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£14 10 0
Ferro-tungsten—	
80/85%	2/6 lb.
Tungsten metal powder—	
98/99%	2/9 lb.
Ferro-chrome—	
2/4% car.	32 0 0
4/6% car.	23 0 0
6/8% car.	21 12 6
8/10% car.	21 12 6
Ferro-chrome—	
Max. 2% car.	34 10 0
Max. 1% car.	35 12 6
Max. 0.70% car.	37 10 0
70% carbon-free	10½d. lb.
Nickel—99.5/100%	£225 to £230
"F" nickel shot	£202 10 0
Ferro-cobalt, 98/99%	5/- lb.
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel				2	10	0
Bundled steel and shrngs.	2	2	6 to 2	10	0	
Mixed iron and steel	2	5	0 to 2	6	0	
Heavy cast iron	2	4	0 to 2	5	0	
Good machinery	2	7	6 to 2	10	0	
Cleveland—						
Heavy steel	2	10	0 to 2	15	0	
Steel turnings				1	15	0
Cast-iron borings				1	5	0
Heavy forge				2	10	0
W.I. piling scrap				2	5	0
Cast-iron scrap	2	11	0 to 2	13	0	
Midlands—						
Light cast-iron scrap				2	2	6
Heavy wrought iron				2	15	0
Steel turnings, f.o.r.				1	12	0
Scotland—						
Heavy steel				2	10	0
Ordinary cast iron	2	8	6 to 2	10	0	
Engineers' turnings				1	17	6
Cast-iron borings				1	18	0
Wrought-iron piling				2	11	3
Heavy machinery				2	13	6

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	26	0	0
Brass	19	10	0
Lead (less usual draft)	10	0	0
Tea lead	7	10	0
Zinc	9	10	0
New aluminium cuttings	70	0	0
Braziery copper	24	0	0
Gunmetal	24	0	0
Hollow pewter	150	0	0
Shaped black pewter	106	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/-
Foundry No. 3	62/6
,, at Falkirk	62/3
,, at Glasgow	65/3
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	63/-
Hematite M/Nos., f.o.t.	62/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	69/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/-
,, No. 3 fdry.	66/-
Northants forge	58/6
,, fdry. No. 3	62/6
,, fdry. No. 1	65/6
Derbyshire forge	62/-
,, fdry. No. 3	66/-
,, fdry. No. 1	69/-
Scotland—	
Foundry No. 1	67/6
,, No. 3	65/-
Hem. M/Nos. d/d	66/-
Sheffield (d/d district)—	
Derby forge	59/6
,, fdry. No. 3	63/6
Lincs forge	59/6
,, fdry. No. 3	63/6
E.C. hematite	76/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	80/-
Clyde, No. 3	80/-
Monkland, No. 3	80/-
Summerlee, No. 3	80/-
Eglinton, No. 3	80/-
Gartsherrie, No. 3	80/-
Shotts, No. 3	80/-

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	0	0 to	9	15	0
Nut and bolt iron	6	17	6 to	7	10	0
Hoops	10	10	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 to	12	0	0
Bolts and nuts, ¾ in. × 4 in.	13	15	0			
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	5	0 to	8	10	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ⅜ in. (Untested)	7	12	6 to	8	5	0
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	0	0
Hoops (Staffs)	10	10	0 & up.			
Black sheets, 24g. (4-t. lots)				10	5	0
Galv. cor. shts. (,,)				12	15	0
Galv. flat shts. (,,)				13	5	0
Galv. fencing wire, 8g. plain				14	0	0
Billets, soft	5	10	0 to	5	15	0
Billets, hard	6	17	6 to	7	2	6
Sheet bars	5	0	0 to	5	10	0
Tin bars				5	0	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	11d.
Sheet to 10 w.g.	12d.
Wire	11⅞d.
Rods	11d.
Tubes	15d.
Castings	13d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	19.26
No. 2 foundry, Valley	17.50
No. 2 foundry, Birm.	13.50
Basic, Valley	17.00
Bessemer	19.76
Malleable, Valley	17.50
Grey forge, Valley	17.50
Ferro-mang. 80%, seaboard	82.00
O.-h. rails, h'y, at mill	36.37½
Billets	26.00
Sheet bars	26.00
Wire rods	36.00
	Cents.
Iron bars, Phila.	1.89
Steel bars	1.75
Tank plates	1.70
Beams, etc.	1.70
Skelp, grooved steel	1.60
Steel hoops	1.85
Sheets, black, No. 24	2.25
Sheets, galv., No. 24	2.85
Wire nails	2.35
Plain wire	2.20
Barbed wire, galv.	2.85
Tinplates, 100-lb. box	$5.25

COKE (at ovens).

Welsh foundry	20/- to 25/-
,, furnace	18/-
Durham foundry	21/- to 25/-
,, furnace	16/6
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14	per box	16/3 to 16/6
,,	28×20	,,	32/6 to 33/-
,,	20×10	,,	23/9 to 24/-
,,	18¾×14	,,	16/10½ to 17/-
C.W.	20×14	,,	15/-
,,	28×20	,,	31/6
,,	20×10	,,	22/-
,,	18¾×14	,,	15/6

SWEDISH CHARCOAL IRON & STEEL.

	£	s.	d.	£	s.	d.
Pig-iron	£6	0	0 to	£7	0	0
Bars-hammered, basis	£16	0	0 to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	0	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£30	0	0 to	£31	0	0
Faggot steel	£18	0	0 to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0 to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Jan.	4 ..	32	1	3	dec.	1/3
,,	5 ..	31	16	3	,,	5/-
,,	8 ..	31	11	3	,,	5/-
,,	9 ..	31	6	3	,,	5/-
,,	10 ..	31	5	0	,,	1/3

Electrolytic Copper.

		£	s.	d.		
Jan.	4 ..	35	5	0	dec.	5/-
,,	5 ..	35	5	0	No change	
,,	8 ..	34	15	0	dec.	10/-
,,	9 ..	34	15	0	No change	
,,	10 ..	34	15	0	,,	,,

Standard Tin (cash).

		£	s.	d.		
Jan.	4 ..	224	17	6	dec.	40/-
,,	5 ..	226	2	6	inc.	25/-
,,	8 ..	224	12	6	dec.	30/-
,,	9 ..	224	5	0	,,	7/6
,,	10 ..	224	7	6	inc.	2/6

Tin (English ingots).

		£	s.	d.		
Jan.	4 ..	225	10	0	dec.	40/-
,,	5 ..	226	15	0	inc.	25/-
,,	8 ..	225	5	0	dec.	30/-
,,	9 ..	224	15	0	,,	10/-
,,	10 ..	224	15	0	No change	

Spelter (ordinary).

		£	s.	d.		
Jan.	4 ..	14	8	9	inc.	1/3
,,	5 ..	14	8	9	No change	
,,	8 ..	14	3	9	dec.	5/-
,,	9 ..	14	3	9	No change	
,,	10 ..	14	6	3	inc.	2/6

Spelter (Electro, 99.9 per cent.).

		£	s.	d.		
Jan.	4 ..	16	15	0	inc.	5/-
,,	5 ..	16	15	0	No change	
,,	8 ..	16	10	0	dec.	5/-
,,	9 ..	16	10	0	No change	
,,	10 ..	16	10	0	,,	,,

Zinc Sheets (English).

		£	s.	d.		
Jan.	4 ..	24	10	0	No change	
,,	5 ..	24	10	0	,,	,,
,,	8 ..	24	10	0	,,	,,
,,	9 ..	24	10	0	,,	,,
,,	10 ..	24	10	0	,,	,,

Lead (English).

		£	s.	d.		
Jan.	4 ..	12	5	0	No change	
,,	5 ..	12	5	0	,,	,,
,,	8 ..	12	0	0	dec.	5/-
,,	9 ..	12	5	0	inc.	5/-
,,	10 ..	12	5	0	No change	

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895	0 12 0	0 12 0	0 11 10	0 12 0	0 12 0	0 12 3	0 12 3	0 12 4	0 12 4	0 12 6	0 12 7	0 12 6	0 12 2½
1896	0 12 6	0 12 6	0 12 9	0 12 9	0 12 9	0 12 7	0 12 9	0 12 9	0 12 9	0 13 6	0 15 0	0 14 9	0 13 1
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 17 6	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 8½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7½
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8½
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 9
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9½
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 3½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 3 6	1 0 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 2 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 3½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 16 0	0 15 8½
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6½	1 1 3	1 1 5	1 0 9½
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 0 11½	0 19 6	0 19 0	0 19 0	0 19 1½	0 19 6	1 0 0½	1 1 6½	1 0 7½
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 3½
1913	1 2 9	1 2 2	1 1 7½	1 1 6	1 0 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 8½
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 8½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 3	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	} Price Fixed												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
1921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17 6	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 13 8½
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 5 3	1 4 9½	1 4 2½	1 3 3½	1 2 6	1 2 3	1 5 3½
1923	1 2 9½	1 4 6½	1 5 2	1 4 8½	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 0	1 3 2½	1 4 9	1 3 10½
1924	1 4 2½	1 4 0	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	1 1 5½	1 1 6	1 1 6	1 1 0	1 1 6	1 1 6	—	1 1 4½
1927	1 2 1½	1 2 3	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 7½	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 7½
1928	1 1 0	1 1 1½	1 1 11	1 2 4½	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 2½
1929	1 2 6	1 2 6½	1 2 11½	1 3 0	1 3 0	1 3 2½	1 4 0	1 4 8½	1 4 7½	1 4 6	1 4 6	1 4 3	1 3 7½
1930	1 3 3½	1 2 6	1 1 9	1 1 6	1 0 10½	1 0 0	1 0 0	0 19 6	0 19 0	0 17 4½	0 16 4½	0 16 4½	0 19 10½
1931	0 16 1½	0 16 0	0 16 0	0 15 11½	0 15 4½	0 15 0½	0 14 10½	0 14 3½	0 14 6	0 16 8½	0 17 0½	0 16 6	0 15 9
1932	0 16 6	0 16 6	0 16 3	0 15 6	0 15 4½	0 15 0	0 14 11	0 14 8½	0 14 6	0 14 6	0 14 9	0 15 1	0 15 3½
1933	0 15 6	0 15 3	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 11½	0 16 6	0 16 6	0 15 7½

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